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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CIX.—No. 2841.] *LONDON: FRIDAY, JUNE 11, 1920.* [*Registered at the General Post Office as a Newspaper.*] [PRICE... 1s. 2d. BY FOREIGN POST... 1s. 5½d.

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Page 127, May 21.

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See page 17, June 4. 8295

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See page 15, June 4.

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6920
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See Advertisement page 101.

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See Advertisement page 38. 8187

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See Illus. Advt. last week, page 15. 7977

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Also TWO 500 Kw. Parsons TURBINES, 230-250 Volts, D.C. (in series 460-500 volts), complete with Spare Armature and Condenser.
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See Full Page Advt., page 91, May 28.
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See Advt. Page 130, June 4.
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The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 8443

The Manchester Steam Users' ASSOCIATION.

The ANNUAL GENERAL MEETING of the Members was held in the Board Room of the Association, at their Offices, 9, Mount Street, Manchester, on Tuesday, June 8th, HAROLD LEE, Esq., J.P. (Manchester), President, in the Chair, when the following Resolutions were adopted:—

Moved by the Chairman, seconded by JAMES S. ADDISON, Esq. (Manchester), and resolved—

"That the Report of the Committee of Management to the Subscribers be adopted."

Moved by JOHN CLARKE, Esq. (Messrs. Henry Tate & Sons, Ltd., London), seconded by EDMUND TETLEY, Esq. (Messrs. Joshua Tetley & Sons, Ltd., Leeds), and resolved—

"That the thanks of the Association are due and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number."

COMMITTEE OF MANAGEMENT.
HAROLD LEE, Esq., J.P., Manchester.
EDWARD HOPKINSON, Esq., D.Sc., M.P., Manchester.
HENRY WHITEHEAD, Esq., M.V.O., Bury.
A. NORMAN DUGDALE, Esq., Blackburn.
FREEMAN B. T. TREVELYAN, Esq., Openshaw.
JAMES S. ADDISON, Esq., Manchester.
J. T. BROWNE, Esq., Pendlebury."

Moved by WILLIAM HERBERT HAIGH, Esq. (The British Dyestuffs Corporation (Huddersfield), Ltd., Huddersfield), seconded by JOHN H. BROOKS, Esq. (The Whitworth Doubling Co., Ltd., Whitworth, Rochdale), and resolved—

"That Messrs. F. W. POPPLEWELL & SON, Chartered Accountants, Manchester, be appointed Auditors of the Association's accounts for 1920."

EDWARD A. BATEMAN, Secretary
9, Mount Street, Albert Square, Manchester.
June 9th, 1920. H 121

Inst. C.E. Exams.—Over 300 successes by Correspondence Coaching.—Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434, Offices of ENGINEERING.

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TENDERS.

AUCKLAND HARBOUR BOARD.
NEW ZEALAND.

Tenders are Invited for the SUPPLY of ONE Two Ton TRUCK CRANE.

Specifications can be obtained on payment of a deposit of Two Guineas, at the office of the Board's Agents, Messrs. W. & A. MCARTHUR, LTD., 18/19, Silk Street, Cripplegate, London, E.C. 2.

Tenders to reach Messrs. W. & A. MCARTHUR, LTD., not later than 31st July, 1920. G 775

BELFAST HARBOUR.

TO DREDGING CONTRACTORS AND DREDGING PLANT OWNERS.

The Belfast Harbour Commissioners are prepared to receive

Alternative Tenders for the under-noted:—

1. For Carrying Out the REMOVAL by DREDGING of at least 750,000 Tons of SPOIL within the Harbour of Belfast, and the conveying and depositing of the said dredged material upon the lands of the Commissioners on the County Down and County Antrim side of the Victoria Channel.

2. The HIRE for a period of at least nine months of a PUMPING ASHORE PLANT; four BARGES of a capacity of not less than 400 tons each for use with same; a Tug Boat, and between 1,500 and 2,000 feet of Pipeline to be used ashore.

3. The Purchase of a Complete Dredging Unit, consisting of a Bucket Ladder Dredger capable of dredging to a depth of at least 40 feet below high water; Pumping Ashore Plant; four Barges of a capacity not less than 400 tons each to be used in conjunction with this Plant; a Tug Boat, and about 1,500 to 2,000 feet of Pipeline.

A. Particulars as to the nature and extent of the work to be performed may be obtained from the Harbour Engineer, Mr. T. S. Gilbert, M.Inst.C.E.

B. Fully detailed particulars of the Plant proposed to be Loaned on Hire or Offered for Sale should be supplied by the parties Tendering, and the price quoted should include delivery at Belfast. Place where plant may be inspected should also be stated.

Tenders, to be enclosed in sealed envelopes, endorsed "Tender for Dredging, &c.," should be addressed to the undersigned, and delivered not later than WEDNESDAY, the 30th June, 1920.

The Commissioners do not bind themselves to accept the lowest or any Tender.

D. J. OWEN,
General Manager and Secretary.

Harbour Office,
Belfast, 3rd June, 1920. H 9

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.
(PLANT AND MACHINERY SECTION.)

For Sale by Public Tender,

ADMIRALTY OIL FUEL INSTALLATION.

Erected at SOUTH QUAY, SOUTH HARBOUR, BLYTH (Northumberland), consisting of FOUR STEEL OIL TANKS, each 30 feet long by 9 feet diameter with length of 7 in. W.I. Pipe line. Purchasers will require to remove the installation from present site.

Drawings can be seen, permits to view and Tender Forms obtained from the Controller, Plant and Machinery Section, Disposal Board, D.B.I.E., Charing Cross Embankment Buildings, London, W.C. 2.

Tenders close on 11th June.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 836

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD,
(PLANT AND MACHINERY SECTION).

TIP WAGONS.

For Sale by Public Tender.

42 Steel, DOUBLE-SIDE TIP WAGONS, 1 yd. flush capacity, 60 c.m. gauge, capable of being slung and tipped while slung, fitted with brakes and spring draw-gear, roller bearings, etc. Lying at C.S. DEPOT 126, Military Wharf, Purfleet, Essex.
41 Steel, 1 yd. SIDE TIP WAGONS, 2 ft. gauge.
15 " ½ yd. " " " " "
Lying at Richboro'.

Permits to view and Tender Forms may be obtained on application to the CONTROLLER, D.B.I.E., Plant and Machinery Section, Charing Cross Huts, Embankment, W.C. 2.

Tenders to be returned not later TEN a.m., JUNE 26th, 1920.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all Bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 976

TENDERS
TO REINFORCED CONCRETE SPECIALISTS, ETC.

The Guardians of the Poor of the Parish of St. Mary, Islington, in the County of London, invite

Tenders from persons willing

to contract for the renewal of foundations of three Lancashire Steam Boilers, 27 ft. long by 7 ft. diameter, at their Infirmary, Highgate Hill, London, N. 19, in accordance with plans and specification.

Copy of the form of Tender, and Bills of Quantities may be obtained from the Consulting Engineer, and the plans and specification and conditions of contract inspected at the Offices of H. R. DOLBY, Esq., M.Inst.C.E., Consulting Engineer, 8 Princes Street, Westminster, S.W. 1, from the 14th to the 16th June 1920, upon depositing the sum of £3, which will be returned on receipt of a bona fide Tender.

Tenders must be sealed up and addressed to the Guardians and delivered at the undermentioned offices not later than 4 p.m. on Friday, the 25th June, 1920, endorsed "Tender for the renewal of Boiler Foundations," and the same will be opened at a meeting of the Guardians.

Each person Tendering must be prepared to give satisfactory references and sureties if required.

The Guardians do not bind themselves to accept the lowest or any Tender.

No contract will be given to firms who do not ordinarily observe the recognised rates of wages and hours of labour.

By Order,
ALBERT KING,
Clerk.

Guardians' Offices,
St. John's, Upper Holloway, N. 19.
5th June, 1920. H 19

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following stores, namely:—

	Specification Fees.
1. Steel work for Bridges.	£1
2. Crank and Straight Axles for Locos.	10/-
3. Brass Sheets, Copper Tubes, &c.	10/-
4. Drawn Brass Angles, &c.	2/6
5. Copper Rods and Ingots.	10/-
6. Pig Iron.	10/-
7. Brass and Iron or Steel Screws.	10/-
8. Carriage Door Handles, Hinges, &c.	7/6

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Work for Bridges," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, 22nd June, 1920.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
42, Copthall Avenue, E.C. 2.
London, 9th June, 1920. H 87

CLYDE NAVIGATION.

TO STEELWORK CONTRACTORS.

The Trustees of the Clyde Navigation invite

Tenders for the Construction of a STEEL FRAMED TWO STOREY GOODS SHED on South Quay, Prince's Dock, Glasgow, 750 feet long by 76 feet wide. The work embraces about 2,400 Tons of Steel in Columns, Girders and Joists, and includes timber piled foundations, Concrete work and Brickwork Panelling.

Drawings may be seen, and Specification, Schedule of Quantities and Form of Tender obtained on application to Mr. P. D. DONALD, the Trustees' Engineer, at his Office here, on a deposit of Five Guineas, which will be refunded on receipt of a bona fide Tender.

Sealed Tenders, marked "Tender for Two Storey Shed, Prince's Dock," to be lodged with the undersigned not later than MONDAY, 5th July, 1920.

The Trustees may not accept the lowest or any Tender.

T. R. MACKENZIE,
General Manager and Secretary.
16, Robertson Street, Glasgow.
9th June, 1920. H 63

METROPOLITAN WATER BOARD.

DISPOSAL OF SPARE PLANT.

The Metropolitan Water Board invite

Tenders for the Purchase and REMOVAL of TWO QUADRUPLE PUMPING ENGINES, &c., fixed at the Wandsworth Pumping Station, the Causeway, Wandsworth, Surrey.

The engines may be seen at the address stated at any time between 9 a.m. and 5 p.m., on week days (Saturday excepted) on application to the Resident Engineer, Batterses Works, Kirtling Street, Nine Elms Lane, Batterses.

A schedule containing particulars of the plant, together with Tender Form and Conditions of Contract may be obtained from the Chief Engineer by personal application or on receipt of a stamped addressed envelope.

Tenders, which must be on the official form, addressed to the CLERK, Metropolitan Water Board, Rosebery Avenue, Clerkenwell, E.C. 2, endorsed "Tender for Disposal of Engines," must be delivered at the offices of the Board not later than Four p.m., on Friday, 25th June, 1920.

The Board do not bind themselves to accept the highest or any Tender.

A. B. PILLING,
Clerk of the Board.

Offices of the Board.
Rosebery Avenue,
Clerkenwell, E.C. 2.
4th June, 1920. H 71

SALE BY TENDER.

To Engineering Concerns desirous of acquiring a New Works with fully equipped New Plant in Manchester.

Re MESSRS. NEWTON-HARPER,
under Dissolution of Partnership.

MOTOR CAR ENGINEERING WORKS
known as
VICTORY WORKS,
STRETFORD, MANCHESTER.

To be Sold by Tender, the above-mentioned recently erected and well-equipped MOTOR CAR ENGINEERING WORKS, with the business and Goodwill thereof, as a going concern, situate at and called "Victory Works," in Stretford, Manchester, and now carried on by the firm of Messrs. Newton-Harper, who are dissolving partnership.

The Works were erected in 1919 and are situate within 3½ miles of the centre of the City of Manchester, on the Chester Road Main Car Route and within a short distance of Stretford and Old Trafford Railway Stations.

The Site contains an area of 14,489 square yards, including street land, and is held on a Lease for 999 years from the Trustees of the Trafford Estate at a yearly rental of £162 7s. 6d. and subject to the usual covenants contained in Leases of the Trafford Estate.

The Buildings are extensive and planned on the most modern lines. All the Machinery and Plant is of the most modern description, while the Electrical power and Lighting installations are of the latest and most approved type.

The Stock in Trade of raw material and finished and unfinished goods will be taken over at a valuation by the purchaser.

In addition the whole of the Patent Rights appertaining to the 12 HP. Newton Chassis (excluding the Italian Rights), and the Drawings and Specifications in connection therewith will be sold with the business.

The above is offered for sale in two separate lots, namely:—

LOT 1, which comprises the Motor Car Engineering Works and the site thereof as aforesaid and all the machinery and fixed and Loose Plant used in connection therewith and the Stock in Trade, the Patent rights of the Newton Chassis, and the Goodwill of the business (except the Goodwill and Stock in Trade attached to Lot 2) as a going concern with the benefit of all pending contracts.

LOT 2. The Goodwill in connection with the specialised manufacture of Broaches for Engineering Works which is now carried on by the firm as a separate Branch of the business and the whole of the Drawings and the benefit of all pending contracts in connection therewith and all the Stock of special steel used in this Department. No Tools or Machinery are included in this Lot.

The name Newton-Harper is excluded from the sale and the Purchaser shall have no right to use such name nor either of such names. Detailed Particulars of the Property and Inventories of the Machinery, Plant, &c., to be sold together with Conditions of Sale and Form of Tender attached, have been printed and may be had on application to any of the undersigned.

Tenders on the Form supplied must be sent in on or before the 1st July, 1920, addressed to FRANK DOWLER, Esq., Chartered Accountant, 5, King Street, Manchester.

All further information that may be desired and orders to view may be obtained from the above named,

FRANK DOWLER, Esq., the Receiver appointed by the Partners,
P. S. AIREY, ENTWISTLE & CO., Auctioneers and Valuers, 10, Norfolk Street, Manchester, or
P. O. S. LEAK & PRATT, Solicitors, 6, John Dalton Street, Manchester. H 120

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

BRIDGEWORK (Two Spans, 50 ft. each, about 45 tons).

Specification and forms of Tender may be obtained at the Company's Offices, 91, York Street, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Bridgework," must be left with the undersigned not later than Two p.m. on Tuesday, the 29th June, 1920.

A charge, which will not be returned, will be made of 20s. for each copy of the Specification. Copies of the drawings may be obtained at the office of ROBERT WHITE, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W. 1.

By Order,
W. B. REYNOLDS,
for Managing Director.

91, York Street,
Westminster, S.W. 1.
9th June, 1920. H 130

PORT OF BRISTOL—NEW ADMINISTRATIVE OFFICES, AVONMOUTH DOCKS.

The Docks Committee are prepared to receive

Tenders for the Construction of ADMINISTRATIVE OFFICES at Avonmouth Docks. The building has a ground floor area of 1200 square yards, and is part three floors and part two floors. The upper floors are of ferro-concrete construction.

On and after Monday next, the 14th inst., copies of the Specification and Contract Drawings can be obtained from the undersigned on production of a sheet showing a deposit of £5 has been paid to the Secretary of the Docks Committee, at 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £5 will be returned to bona fide tenderers after the receipt of the tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Administrative Offices," and addressed to the Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Monday, the 5th July, 1920. The Docks Committee do not bind themselves to accept the lowest or any tender.

THOMAS A. PEACE,
Engineer.

Engineer's Offices,
Avonmouth Dock,
9th June, 1920. H 125

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

FOR SALE BY PUBLIC TENDER
OIL FUEL INSTALLATION.

Tenders are Invited for the following:—

ADMIRALTY OIL FUEL INSTALLATION, erected in 1916, on land adjacent to Alexandra Dock, Hull, known as Hedon Road Reservation, consisting of STEEL TANK, 80 ft. dia. by 30 ft. deep, with C.-I. pipe lines, from 5 in. to 15 in. dia., running under or along the adjacent land and jetty. The PUMP HOUSE 31 ft. 6 in. by 23 ft. 6 in. contains 2 Hayward Tyler Pumps, each direct coupled to moter.

The Hull Corperation are prepared to negotiate with a reputable purchaser for a lease of the land on which part of this installation stands (including Tank and Pump House) for a term of 50 years with option of renewal for a further 25 years, but the pipe lines which run along jetty will require to be removed.

Drawings and Specifications can be seen, permits to view and Tender Forms obtained from the CONTROLLER, Plant and Machinery Section of Disposal Board (D.B.I.e.), Charing Cross Embankment Buildings, London, W.C. 2.

Tenders close on June 14th, 1920.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 760

APPOINTMENTS OPEN.

LONDON COUNTY COUNCIL.

There is a Vacancy for a LECTURER in ENGINEERING SUBJECTS at the L.C.C. Hackney Institute, Dalston Lane, E. 8, for three evening attendances a week. Fee 15s. an attendance (about three hours). A knowledge of Mechanics and Heat Engines is desirable. The successful candidate will be required to take up his duties in September next.

Preference will be given to candidates who have served, or attempted to serve, with H.M. Forces. Application forms may be obtained from the Education Officer (T. 1), Education Offices, Victoria Embankment, W.C. 2. (Stamped addressed foolscap envelope necessary.) Form must be returned by 11 a.m. on 16th June, 1920. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
G 905

WOLVERHAMPTON EDUCATION COMMITTEE

MUNICIPAL TECHNICAL SCHOOL.

Wanted, in September next, a FULL-TIME LECTURER in MECHANICAL ENGINEERING. University degree, or its equivalent, and teaching experience essential. Salary £300, rising by annual increments of £25 to a maximum of £400. Application form and further particulars can be obtained upon sending stamped addressed foolscap envelope to the undersigned. Applications must be received by not later than 30th June, 1920. Canvassing prohibited.

T. A. WARREN,
Director of Education.

Education Offices,
Town Hall,
Wolverhampton.
7th June, 1920. H 98

THE DESIGN OF A LONG-SPAN REINFORCED CONCRETE GIRDER.

By A. E. WYNN, B.Sc., Assoc.M.Am.Soc.C.E.

IN the United States there is a tendency towards long-span construction, especially for certain types of buildings. A clear floor without any obstructing columns is very desirable for such buildings as auditoriums, gymnasiums, market halls, boiler rooms, foundries, &c.

Hitherto these long spans have always been constructed in structural steel; but during the war structural steel was difficult to obtain and high in price, so that it became economical to use reinforced concrete wherever possible. Long-span construction has been developed and used extensively on the Continent, but one seldom sees an article on it in the English language.

To compete successfully with steel it is necessary to design with the utmost economy, and this means a knowledge of "frame" design. By this method concrete girders can be designed safely and economically up to 60 ft. span and over.

The average designer would probably design the girder for a bending moment of $\frac{wl}{8}$ and the columns for the total vertical load only, increasing them in size according to his judgment, to take care of the bending moment. This will usually result in a girder which is too strong and columns which are too weak, and there will be no economy of material.

If a permanent joint is constructed between the girder and column, this method of design would be correct, but it is not desirable, as one of the advantages of reinforced concrete is its monolithic character. Since, then, the girder and columns are poured together, forming one monolithic "frame," negative moments occur at the ends of the girder, and the columns are under stress due to bending as well as direct load. It is neither economical nor good design to neglect these negative moments.

In the columns especially, very high stresses may occur. Long spans occur most frequently in roof design, where the live load is small. If the columns are designed for direct loads only it will be found that the stress in the concrete is small, perhaps 200 lb. per square inch, and the designer may think there is a very large factor of safety; actually, if the stress due to bending is added, it will be found that the combined stress is very high, perhaps 1,000 lb. or more per square inch.

In designing the girder, advantage can be taken of the fact that the negative moments will reduce the maximum positive moment in the girder. The problem in designing a frame consists in determining the amount of negative moment at the junction of girder and columns. This will depend upon the relative stiffness of girder and column, the stiffness being measured by the ratio of the moment of inertia of the member to its length.

It will also depend upon the degree of fixation at the bottom of the columns. The columns can be designed as either free or fixed at the lower ends, according to conditions, and the judgment of the designer. Neither condition will exist absolutely, so it is best to design the girder, assuming the ends of the columns free, as this will give the maximum positive moment; and the columns with fixed ends giving the maximum positive and negative moments in the columns.

A frame of this kind is statically indeterminate, but by either the "slope and deflection" methods or by the "theory of least work" an expression can be found for the horizontal thrust at the base of the column. Knowing the amount of this thrust the moment at any point in the frame can easily be found by taking moments about the point.

The steps necessary in designing a frame of this kind are as follows: (1) Assume size and reinforcing of girder and columns, these can be guessed fairly closely after a little practice in frame design. (2) Assume maximum positive moment in the girder as, say, $\frac{wl}{12}$, and design girder for this moment, correcting the assumed size if necessary. Work out the size of "tee" required for compression. (3) Find neutral axis of girder. (4) Find moment of inertia of T-beam about neutral axis. (5) Find average moment of inertia of columns. (6) Find ratio of stiffness of girder to stiffness of column, taking the centre line of the frame for the respective lengths. (7) Find horizontal thrust from

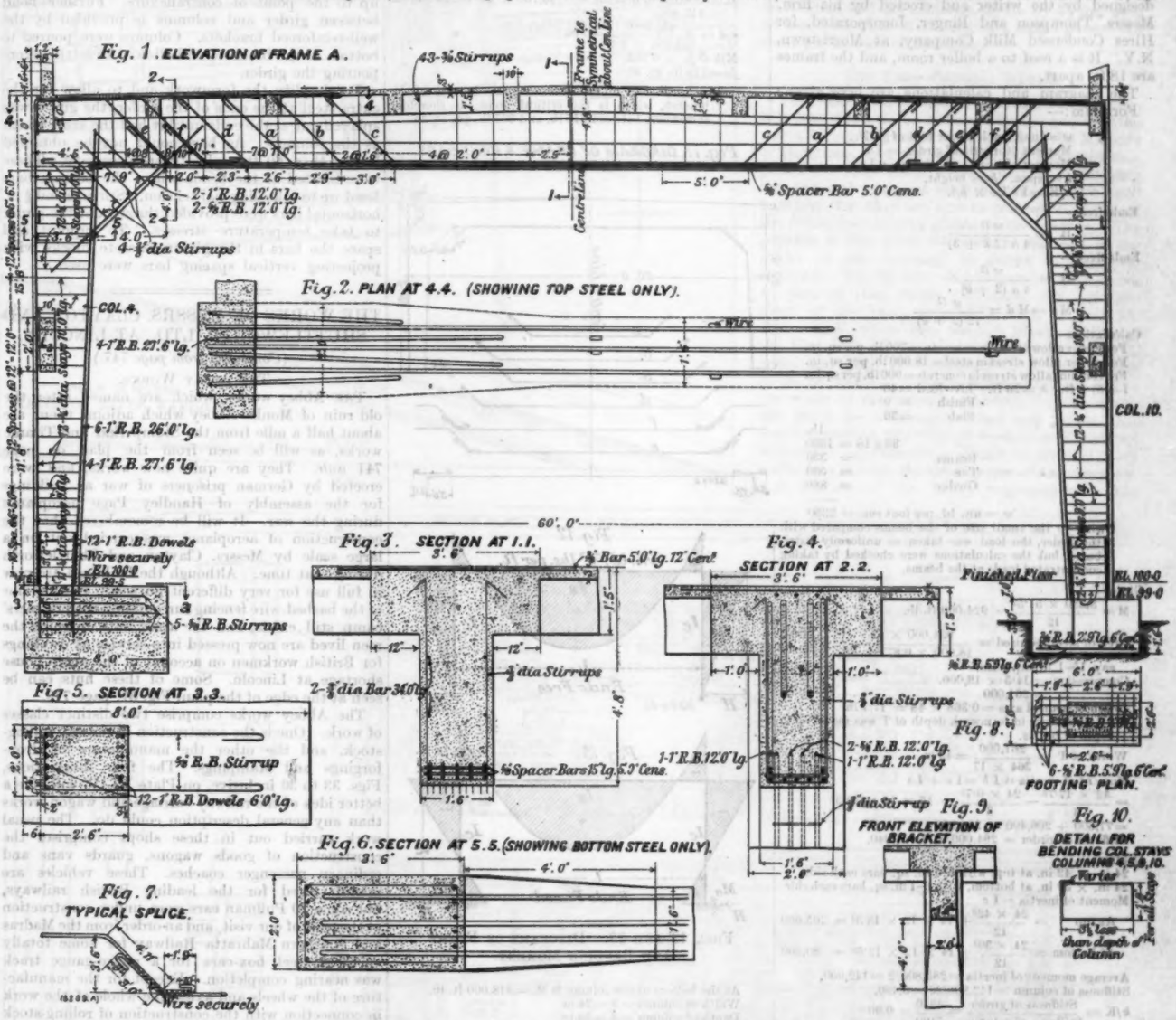


Fig. 1. ELEVATION OF FRAME A.
43-⅜ Stirrups
Frame to Symmetrical about Centre Line
Centre Line
5'. 0"
⅜ Spacer Bar 5'.0" Cens.
2-1" R.B. 12'.0" lg.
2-⅜ R.B. 12'.0" lg.
4-⅜ dia. Stirrups
COL. 4.
COL. 10.
4-1" R.B. 27'.6" lg.
6-1" R.B. 26'.0" lg.
4-1" R.B. 27'.6" lg.
60'. 0"
Fig. 2. PLAN AT 4.4. (SHOWING TOP STEEL ONLY).
Wire
Fig. 3. SECTION AT 1.1.
12-1" R.B. Dowels
Wire securely
5-⅜ R.B. Stirrups
⅜ Bar 5'.0" lg. 12" Cent.
⅜ dia Stirrups
2-⅜ dia Bar 34'.0" lg.
Fig. 4. SECTION AT 2.2.
Finished Floor
⅜ R.B. 5'.9" lg. 6" Cent.
⅜ dia Stirrups
2-⅜ R.B. 12'.0" lg.
1-1" R.B. 12'.0" lg.
Fig. 5. SECTION AT 3.3.
⅜ R.B. Stirrup
12-1" R.B. Dowels 6'.0" lg.
Fig. 6. SECTION AT 5.5. (SHOWING BOTTOM STEEL ONLY).
Fig. 7. TYPICAL SPLICE.
Wire securely
Fig. 8.
6-⅜ R.B. 5'.9" lg. 6" Cent.
FOOTING PLAN.
Fig. 9. FRONT ELEVATION OF BRACKET.
Fig. 10. DETAIL FOR BENDING COL. STAYS COLUMNS 4, 5, 9, 10.
Varies
¾" Less than depth of Column

formulæ given below. These are derived from either of the two methods mentioned. (8) Find maximum positive moment in the girder by taking moments about the centre line, this will be the true moment by which to check the assumed values. (9) Find negative moments, top and bottom of columns; calculate stress in columns due to bending and direct load. If the stress is too high or too low the size or reinforcing of the columns must be changed and the calculations repeated. It will probably take two or three trials to obtain the best proportions of girder and columns. The frame illustrated in the engravings on page 777 was designed by the writer and erected by his firm, Messrs. Thompson and Binger, Incorporated, for Hires Condensed Milk Company, at Morristown, N.Y. It is a roof to a boiler room, and the frames are 18 ft. apart.

The diagram and calculations are here given: Formulæ:—

w = uniform load per foot of girder.
Moment of inertia of girder = $I\,b$.
Moment of inertia of column = $I\,c$.
l = span. h = height.
$h/K = I\,b/I\,c \times h/l$.

Ends free—

$$H = \frac{w\,l^2}{4\,h\,(2\,h + 3)}$$

Ends fixed—

$$H = \frac{w\,l^2}{4\,h\,(2 + k)}$$

$$M\,a = M\,d = \frac{w\,l^2}{12\,(2 + k)}$$

Calculations—
For girder allow stress in concrete = 700 lb. per sq. in.
For girder allow stress in steel = 18,000 lb. per sq. in.
For columns allow stress in concrete = 900 lb. per sq. in.
l = 57·5 ft. h = 26 ft. Live load = 40

		lb.
	Finish = 9	
	Slab = 36	
		85 × 18 = 1530
Beams		= 350
Tee		= 590
Girder		= 880
		w = un. ld. per foot run = 3350

Owing to the small size of the beams compared with the girder, the load was taken as uniformly distributed, but the calculations were checked by taking concentrated loads at the beams.

Girder—

$$M = \frac{3{,}350 \times 57{\cdot}5^2}{12} = 924{,}000 \text{ ft.-lb.}$$

$$\text{Area of steel required} = \frac{924{,}000 \times 12}{18{,}000 \times 0{\cdot}877 \times 48} = 14{\cdot}5 \text{ sq. in.}$$

say 15–1 in. sq. bars.
Compression = 14·5 × 18,000.
= 261,000
Depth of neutral axis = 0·363 × 48 = 17·7 in.
For convenience in formwork depth of T was made = to depth of beams.

$$\text{Width of T} = \frac{261{,}000}{364 \times 17} = 42 \text{ in.}$$

Moment of inertia = $I\,b = I\,c + I\,s$

$$= \frac{42 \times 17{\cdot}7^3}{3} - \frac{24 \times 0{\cdot}7^3}{3} + 15 \times 15 \times 30{\cdot}3^2$$

= 77,600 + 206,400 = 284,000
Stiffness of girder = 284,000/57·5 = 4,940.

Columns—
24 in. × 42 in. at top, with 6–1 in. sq. bars each side.
24 in. × 30 in. at bottom, with 6–1 in. sq. bars each side.
Moment of inertia = $I\,c$

$$\text{At top} = \frac{24 \times 42^3}{12} + 14 \times 12 \times 18{\cdot}5^2 = 205{,}600$$

$$\text{At bottom} = \frac{24 \times 30^3}{12} + 14 \times 12 \times 12{\cdot}5^2 = 80{,}200$$

Average moment of inertia = 285,800/2 = 142,900.
Stiffness of column = 142,900/26 = 5,490.

$$h/K = \frac{\text{Stiffness of girder}}{\text{Stiffness of column}} = \frac{4940}{5490} = 0{\cdot}90$$

Assuming ends of columns free—

$$H = w\,l^2/4\,h\,(2\,h + 3) = \frac{3{,}350 \times 57{\cdot}5^2}{4 \times 26 \times 4{\cdot}8} = 22{,}200$$

Maximum moment at centre line of girder

$$= w\,l^2/8 - H\,h$$

$$= \frac{3{,}350 \times 57{\cdot}5^2}{8} - 22{,}200 \times 26$$

= 809,000 ft.-lb.

Correct area of steel required = 12·7 sq. in.
Hence our allowance of 15–1 in. sq. bars is amply sufficient.
The correct moment for which to design the girder = $w\,l^2/13{\cdot}7$.

Stress in columns—
Height to bottom of bracket = 20 ft.
B.M. at bottom of bracket = 22,200 × 20 = 444,000 ft.-lb.
Total vertical load above bracket = 123,900 lb.
Width of column = b = 24 in.
Depth of column = d = 42 in.

Percentage of steel on one side = 600/24 × 42
= 0·60 per cent.

Eccentricity = e = 444,000/123,900 = 3·6
e/d = 3·6/3·5 = 1·03

From table giving values of $M/b\,d^2\,f_c$ for different values of e/d and percentages of steel we obtain $M/b\,d^2\,f_c$ = 0·146.

$$\text{Hence } f_c = \frac{444{,}000 \times 12}{24 \times 42^2 \times 0{\cdot}146} = 865 \text{ lb. sq. in.}$$

Assuming ends of columns fixed—

$$H = w\,l^2/4\,h\,(2 + k) = \frac{3{,}350 \times 57{\cdot}5^2}{4 \times 26 \times 2{\cdot}9} = 36{,}700$$

B.M. bottom of column = $M_a = M_d = w\,l^2/12\,(2 + k)$ = + 318,000.
B.M. bottom of bracket = − 36,700 × 20 + 318,000 = − 416,000.

$$e/d = \frac{416{,}000}{123{,}900 \times 3{\cdot}5} = 0{\cdot}96$$

$M/b\,d^2\,f_c$ = 0·145.
f_c = 715 lb. sq. in.

The true stress in the concrete at the bottom of the bracket, which is the critical point, is therefore somewhere between 815 lb. and 865 lb. per sq. in.

Fig. 11. DIAGRAM OF FRAME & BENT BARS. (SHOWING SPLICES).

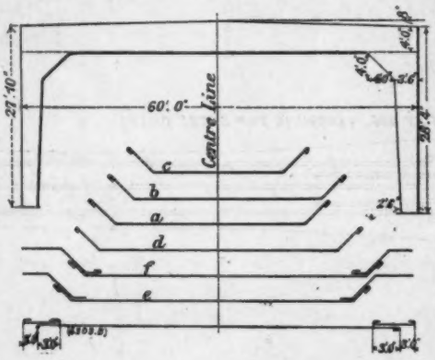


Fig. 12
vn. ld. "w" lbs. per ft.

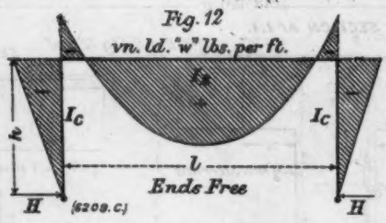
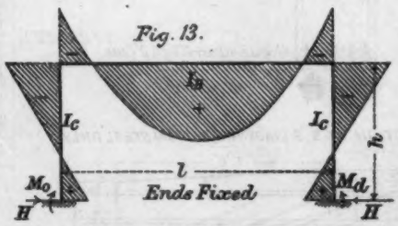


Fig. 13.



FIGS. 12 AND 13. DIAGRAMS OF FRAME AND BENDING MOMENT.

At the bottom of the column B.M. = 318,000 ft.-lb.
Width of column = b = 24 in.
Depth of column = d = 30 in.
Percentage of steel on one side = p = 600/24 × 30 = 0.835

$$e/d = \frac{318{,}000}{143{,}000 \times 2{\cdot}5} = 0{\cdot}89$$

$M/b\,d^2\,f_c$ = 0·169.
f_c = 1045 lb. sq. in.

This stress may seem high, but absolute fixation does not occur, and the bending moment decreases rapidly.

It is necessary to take care of the thrusts at the bottoms of the columns. One column rested on a retaining wall under water pressure on one side and earth pressure on the other. The other column was carried by a footing designed to take the eccentric thrust due to combining the horizontal thrust with the vertical load.

If the girder had been designed for a moment of $\frac{w\,l}{8}$, it would have required 45 per cent. more steel and a "T" 64 in. wide, which would have added considerable concrete and deadweight.

The stress at the top of the column due to vertical load only is 105 lb. per square inch, whereas the true stress is 865 lb. per square inch.

Practical Details.—It is essential that there should be a good bond between the girder and columns, so two bars on the outside of the columns are bent over into the top of the girder and two extra bars, L-shaped, are placed in the corners, the longer leg being in the top of girder and the shorter leg on the outside of the columns. These bars in the top of the girder also take care of the negative moment up to the point of contraflexure. Further bond between girder and columns is provided by the well-reinforced brackets. Columns were poured to bottom of the brackets and allowed to settle before pouring the girder.

To simplify the formwork and to allow for the extra steel at the ends of the girder, the girder was splayed out at the ends until it had the same width as the columns. As bars could not be obtained longer than 60 ft., splices were necessary. These were located at the bends where the bottom bars bend up to take diagonal tension. Stirrups and $\frac{3}{8}$ in. horizontal bars were provided throughout the girder to take temperature stresses. To support and space the bars in the girder concrete blocks with projecting vertical spacing bars were used.

THE WORKS OF MESSRS. CLAYTON AND SHUTTLEWORTH, LTD., AT LINCOLN.

(*Concluded from page* 747.)

THE ABBEY WORKS.

THE Abbey works, which are named after the old ruin of Monks Abbey which adjoins them, are about half a mile from the Stamp End and Titanic works, as will be seen from the plan on page 741 *ante*. They are quite new works, and were erected by German prisoners of war as buildings for the assembly of Handley Page aeroplanes during the war. It will be remembered that the construction of aeroplanes was carried out on a large scale by Messrs. Clayton and Shuttleworth during that time. Although the buildings are now in full use for very different purposes, the remains of the barbed-wire fencing surrounding the prisoners' camp still exists, and the army huts in which the men lived are now pressed into service as dwellings for British workmen on account of the acute house shortage at Lincoln. Some of these huts can be seen at the edge of the plan, Fig. 31, page 779.

The Abbey works comprise two distinct classes of work. One is the construction of railway rolling-stock, and the other the manufacture of drop-forgings and stampings. The four illustrations, Figs. 33 to 36 inclusive, on Plate XLIV, will give a better idea of the railway carriage and wagon works than any general description could do. The usual work carried out in these shops comprises the construction of goods wagons, guards vans and ordinary passenger coaches. These vehicles are manufactured for the leading British railways, but some 20 Pullman cars were under construction at the time of our visit, and an order from the Madras and Southern Mahratta Railway for some totally enclosed steel box-cars for a metre-gauge track was nearing completion. Except for the manufacture of the wheels and axles, the whole of the work in connection with the construction of rolling-stock is carried out by the firm. Their own steel foundry, and particularly their shops for the production of drop stampings and steel forgings, which are situated close by the carriage shops, provide them with valuable facilities for the work. The Abbey carriage works has its own machine-shop and tool-room, but there is nothing especially to be remarked about their equipment. The whole of the carriage works is practically one large open shop 450 ft. wide by 500 ft. long, with the various bays allocated to different processes of manufacture.

Fig. 33, on Plate XLIV, shows the bar-preparation shop, with the erecting-shop in the background. In the photograph can be seen an eight-head girder drilling-machine, while on the extreme left of the illustration is included a part of a beam-end miller by Messrs. Wilkins and Mitchell. This consists

of two separate and adjustable milling-machines, each independently motor-driven, but both mounted on the same long bed-plate. Each carries two milling cutters, and the whole machine will simultaneously square-up the ends of channels and angles of any size and at the same time mill off the ends of the flanges for the purpose of making a joint. Other machines include a large guillotine shears, a set of 8-ft. straightener rolls, besides numerous punching, cropping and shearing machines, drills, &c. In the foreground of the photograph is shown the plate-levelling table.

The saw-mill, illustrated in Fig. 34, Plate XLIV, has an arched roof of 80-ft. span. It contains the usual planers, spindling-machines, and saws which are to be found in shops of this type. The illustration shows some roofs for 10-ton covered goods wagons in course of manufacture. Fig. 35 shows the bay which forms the under-frame shop, but the shop itself is somewhat obscured by the stores of timber in the foreground. Material comes to this shop from the bar-preparation shop, and here the assembly and rivetting up of the steel under-frames takes place. Both hydraulic and pneumatic rivetting are employed. A 5-ton electric crane now traverses the length of this bay. A bay of the erecting-shop is shown in Fig. 36. There are to be seen several 20-ton brake vans for the Caledonian Railway in process of erection as well as a passenger-coach which has come in for refitting. At the time of our visit several Pullman cars were in various stages of erection, and the fine pieces of timber used in their construction were worthy of note. The sole-bars, 7 in. by 5 in. section, were 57 ft. 6 in. long in one piece, the longitudinals, 5½ in. by 4 in. in section, were only 6 in. shorter. The truss planks, also in one piece, 10½ in. by 2 in. in section, were 57 ft. long, and the cantrails, 3½ in. by 2½ in., were no less than 63 ft. 6 in. long in a single piece. All these pieces were of pitchpine.

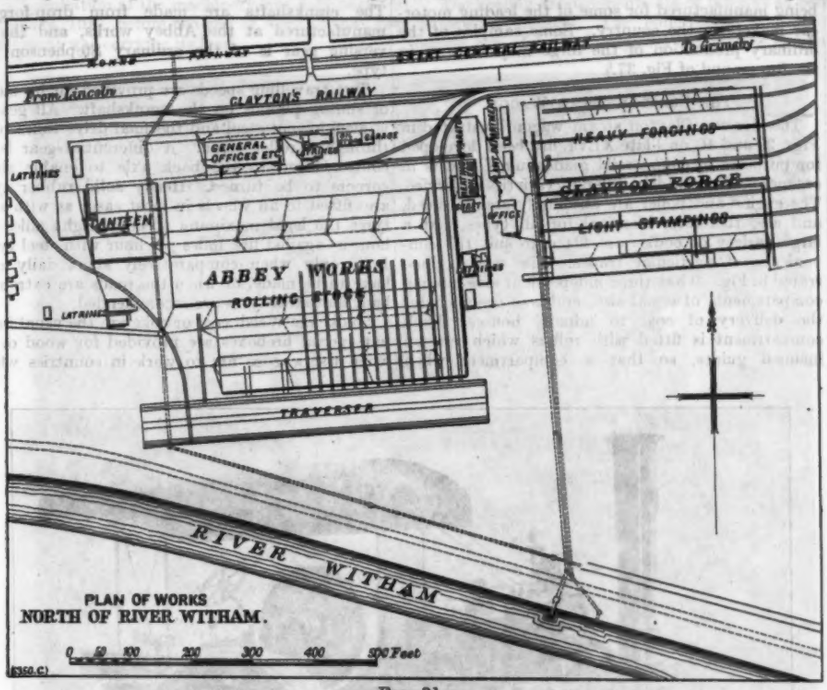


FIG. 31.

THE DROP-FORGING WORKS.

The manufacture of drop stampings and steel forgings was taken up by Messrs. Clayton and Shuttleworth during the war at the request of the Ministry of Munitions, and not only did the firm achieve a productive stage within a very short time, but they laid out and equipped their new works with such foresight that they are now in possession of one of the finest drop-forging plants in the country. The position of this plant relatively to the rest of the works of the company is shown in Fig. 31, annexed. Fig. 32, also on the present page, gives a plan of the shops indicating the arrangement of the tools, &c., while Figs. 37 and 38, Plate XLV, show two interior views. Each of the two main buildings is 350 ft. long by 120 ft. wide, and they are separated by a passage-way 35 ft. in width. A narrow-gauge railway serves the whole of the plant, and standard-gauge tracks also enter the buildings so that coal, billets, &c., may be received, and finished stampings dispatched with every convenience. These tracks also carry traffic to and from the other works of the company.

A feature of the heavy forging-shop is that

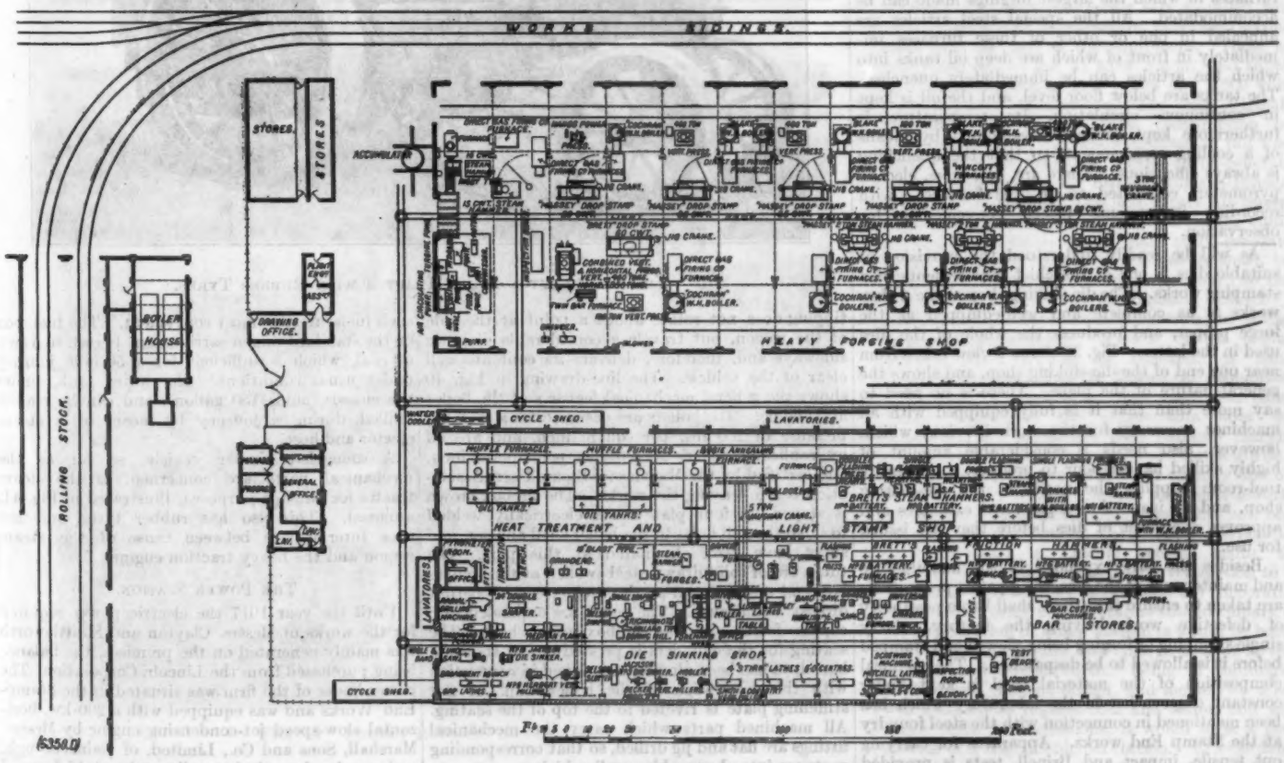


FIG. 32.

all the forging units are complete in themselves, and make, with their own furnaces, self-contained plants. The furnaces are coal-fired, and all are connected with waste heat boilers in which steam is raised for operating the numerous steam-hammers and the engines for driving the drop-stamps. The waste heat boilers, most of which are of the Cochran

type, supply steam to a common main, so that, should any furnace be shut down, the hammer belonging to that unit is still operable. There are in all 16 waste heat boilers in this shop. The largest steam-hammer is a Massey hammer of three tons, but there are also two of two tons each by the same makers. There is also one 80-cwt. drop-stamp, the heaviest of its type in the plant, and five others ranging from 65 cwt. to 50 cwt. in weight. Most of these were supplied by Messrs. B. and S. Massey, Limited, but two were procured from the Brett Patent Lifter Company. Numerous hydraulic presses, ranging from 400 tons to 150 tons, are provided for the classes of work for which pressure, rather than hammering, is necessary. One of these presses has both vertical and horizontal cylinders, and is used for such work as pressing-out a heavy flange on a crankshaft. The shaft is held in suitable dies by the vertical ram while the horizontal ram comes forward with a die which passes over the end of the crankshaft and exercises an "upsetting" pressure which squeezes out the metal into a suitable circular recess left between the two pairs of dies as they come in contact. A 5-ton overhead crane travels down the centre of the heavy stamping-shop and jib cranes are installed for passing the heated billets to the hammers and presses in a rapid and direct manner.

In the light stamping-shop, which is 75 ft. in width, the general lay-out is somewhat similar to that in the other shop, the stamps being arranged in batteries with their waste heat boilers. The heaviest stamps in this shop are of 30 cwt., and they range in weight down to 5 cwt. Altogether in the two shops there are 30 stamps, ranging from 5 cwt. to 4 tons.

As most of the stampings are made from alloy steels, a careful and systematic heat treatment has to be provided for in order to produce in the metal the particular qualities desired. There is at one end of the forge a set of five coal-fired muffle furnaces in which the largest forgings made can be accommodated. All the special steel articles are annealed in one or other of these furnaces immediately in front of which are deep oil tanks into which the articles can be immediately quenched. The tanks are below floor level, and the oil is kept in continuous circulation. Its temperature is furthermore kept between close limits by means of a cooling arrangement, so that the quenching is always efficacious. There are, of course, electric pyrometers connected to all the furnaces, with recording instruments placed conveniently for observation.

As will be readily understood the provision of suitable dies is one of the chief requirements of a stamping works. The die-sinking shop at the Abbey works is as complete and well-equipped as the forge proper, and produces the whole of the dies used in the latter. Fig. 38 shows a view taken from near one end of the die-sinking shop, and shows the general nature of the place. There is no need to say more than that it is fully equipped with all machines necessary for the work in view, which, however, also needs a considerable amount of highly skilled hand-labour to produce. A separate tool-room supplies the needs of the die-cutting shop, and an inspection department examines and approves every set of dies before they are issued for use.

Besides the care expended in the manufacture and maintenance of the dies, the greatest precautions are taken to ensure that there shall be no possibility of defective work leaving the factory. Every single stamping or forging being viewed and stamped before it is allowed to be despatched. The chemical composition of the material used is kept under constant observation in the laboratory which has been mentioned in connection with the steel foundry at the Stamp End works. Apparatus for carrying out tensile, impact and Brinell tests is provided in a small separate test-room, near to the forge, so that the physical properties of the finished products may be continually checked, to see that the required quality is maintained.

Taking all classes of work together, the weekly output of the stamping works is about 80 tons. In addition to the stampings required for their own manufactures, Messrs. Clayton and Shuttleworth supply large quantities to outside firms and particularly to motor-car manufacturers. Crankshafts and front axles, neither of which is a particularly easy thing to make, form quite a considerable item in the whole output, these articles being manufactured for some of the leading motor-car makers in the country. Some samples of the ordinary production of the forge may be seen in the foreground of Fig. 37.

The Clayton Steam Wagon.

The five-ton Clayton steam wagon illustrated in Figs. 39 and 40, on Plate XLVI, has been developed for purposes of commercial road haulage and is in extended use for widely different varieties of service. The engine and boiler are absolutely standardised, and are, therefore, identical for all types, but a large variety of bodies are fitted to suit the convenience of particular trades. The wagon illustrated in Fig. 39 has three independent side-tipping compartments of equal size, and was designed for the delivery of coal to miners' houses. Each compartment is fitted with rollers which run on inclined guides, so that a compartment when tipping does not rotate about a point at the side of the wagon, but travels a considerable distance sideways and, therefore, delivers its contents well clear of the vehicle. The line-drawing in Fig. 40 shows the general mechanical features of the boiler and engine. The boilers are designed for a working pressure of 200 lbs. per square inch, and are all hydraulically tested to 400 lbs. per square inch, and certified by the Manchester Steam Users Association before leaving the works. The firebox crown is stayed by four plate stays electrically welded to it, so that all holes in the boiler shell and screwed stays have been eliminated at this part. The tubes are of solid drawn steel swelled at the smoke-box end and reduced at the firebox end to permit of easy withdrawal. The tubes are expanded into copper ferrules in the firebox tube sheet. The seating for the cylinders is pressed out of the solid barrel, as has been already mentioned in connection with the description of the boiler-shop. A flat stiffening plate is riveted to the top of the seating. All machined parts which carry the mechanical fittings are flat and jig drilled, so that corresponding parts are interchangeable on all vehicles.

The engine is of the two-cylinder compound type with piston-valves. Both cylinders are jacketted by the high-pressure steam, and any steam condensing in the casting drains back to the boiler. The stop valve is above the cylinders, and also controls the opening of a small auxiliary port which admits live steam to the low-pressure cylinder when desired, enabling the engine to exert about double its normal power in emergencies. Each piston with its rod is made of a single drop-forging of high-tensile steel, finished to size by grinding. The crossheads run in circular bored guides which register into the cylinder casting. The crankshafts are made from drop-forgings manufactured at the Abbey works, and the reversing gear is of the ordinary Stephenson link type.

Two travelling speeds are provided for by means of sliding pinions on the crankshaft. All gearing is machine-cut steel and the final drive takes place through a roller chain. A differential gear is, of course, fitted to the back axle to enable sharp corners to be turned. Heavy solid rubber tyres are fitted to all wheels in most cases as with such tyres the legal maximum speed is eight miles per hour as against five miles per hour with steel tyres. It is only when comparatively short daily runs have to be made, or when the roads are extremely bad, that steel tyres are recommended.

Smokeless Welsh coal or coke are the usual fuels, but special fireboxes are provided for wood or oil when the wagons are to work in countries where such fuels are the most convenient. The fuel box on the standard wagon carries from 4½ cwt. to 5 cwt. of coal, which is sufficient for a 50-mile journey under usual conditions. The water tank, under the chassis, holds 150 gallons, and can be readily refilled during a journey by means of a steam ejector and hose.

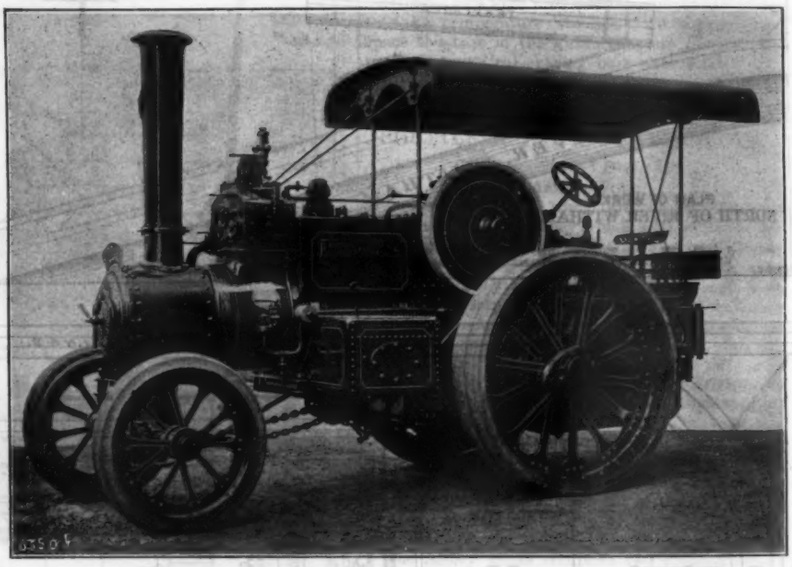


FIG. 41. CLAYTON-STEAM TRACTOR WITH RUBBER TYRES.

A somewhat similar vehicle, so far as the mechanical parts are concerned, is the steam tractor for haulage purposes, illustrated in Fig. 41, annexed. This also has rubber tyres, and has uses intermediate between those of the steam wagon and the heavy traction engine.

The Power Station.

Until the year 1917 the electric power required for the works of Messrs. Clayton and Shuttleworth was mainly generated on the premises, the balance being purchased from the Lincoln Corporation. The power-house of the firm was situated in the Stamp-End Works and was equipped with a 200-kw. horizontal slow-speed jet-condensing engine by Messrs. Marshall, Sons and Co., Limited, of Gainsborough, and a pair of vertical, totally-enclosed high-speed engines of similar capacity, by Messrs. Allen, Son and Co., Limited, of Bedford. In 1916 an urgent need arose for more power, and as the corporation were not in a position to supply it, nor to meet similar demands from the other large manufacturers of the city, Messrs. Clayton and Shuttleworth, Limited, decided to build a new power station themselves. They were fortunately able to purchase the complete

equipment of a power-house which had been put down a few years before by a mining company in the North of England, but for which the company had no further use. A suitable building was erected on the north bank of the River Witham, and although the installation of the machinery was only begun in January, 1917, before the end of April of that year the plant was carrying its load.

FIG. 42. BOILER ROOM OF POWER STATION.

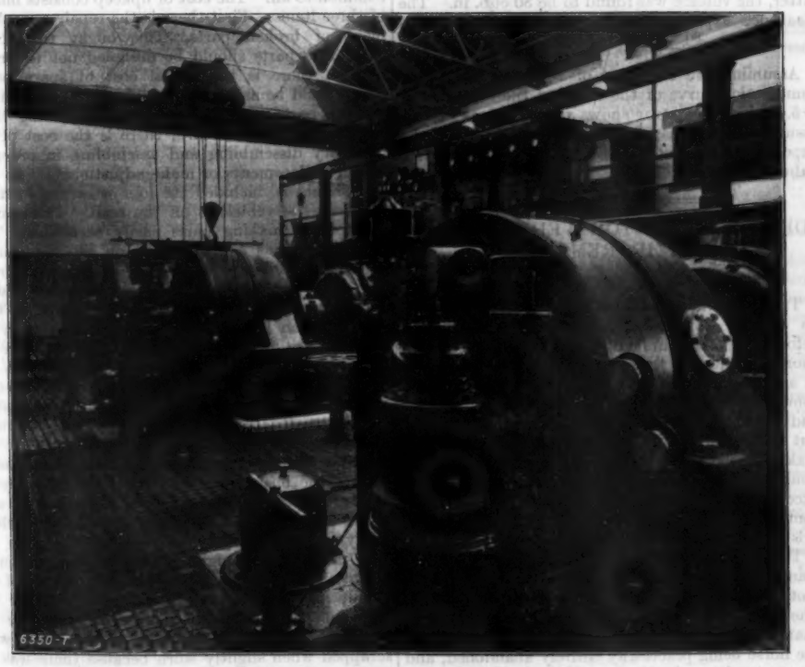


FIG. 43. ENGINE ROOM OF POWER STATION.

Circumstances dictated the site chosen for the plant, and though it was suitable from many points of view it suffered from the fact that being on a swamp a large amount of piling work had to be done. This, however, was thoroughly carried out, and no difficulty with the foundation has been experienced. The double row of piles beneath each wall were tied together at the ends to give mutual support, and the whole were then embedded in concrete by filling in the trench in which the piles were driven. A similar kind of construction was employed beneath the foundations of the boilers and of the generating machinery.

The coaling arrangements are of interest as being somewhat unusual. The boiler-house contains a single row of boilers only and outside the external wall is a large concrete hopper extending along the length of the boiler-room. The cars of coal run over the top of this hopper, and their contents are dumped into it. The hopper has a capacity of about 500 tons of coal. Opposite each boiler is a small elevator which raises the coal required by that particular boiler and delivers it into a separate small overhead bunker holding about 8 tons, passing on its way through an automatic weighing and registering machine. The automatic weighing machines are of Messrs. Clayton and Shuttleworth's own design and manufacture. From the bunker it descends through a pair of shoots to the hopper of the corresponding mechanical stoker.

The whole arrangement has many advantages, particularly for single-sided boiler houses. The separate elevators are small and light, and the absence of large overhead bunkers permits of good illumination, a feature which is not always considered sufficiently in a boiler-house. Reference to Fig. 42, annexed, will show how well lighted this part of the plant is, especially as regards the tops of the boilers and the fronts of the drums, which are often in darkness. The small individual bunkers are clearly shown resting on the cross-girders and on the right-hand side of the illustration can be seen the elevators which feed them.

The original boiler plant consisted of three Babcock and Wilcox water-tube boilers, each with a heating surface of 4,020 sq. ft., and with a rated evaporation of 15,000 lb. of water per hour. Each is fitted with a chain grate stoker and superheater and supplies steam at a pressure of 180 lb. per square inch and a temperature of 572 deg. F. There are now four boilers, the one latest installed having a rated capacity of 25,000 lb. of steam per hour. Every boiler is fitted with its own draught gauge and CO_2 recorder. As the condensed steam is carefully conserved and returned to the boilers, the amount of raw make-up water is kept within limits which render the use of a water-softening plant unnecessary. Two direct-acting Weir pumps and a motor-driven centrifugal Mather and Platt pump supply the boiler feed, which passes through a Green's economiser on its way to the boilers.

The engine-room, which runs parallel to the boiler-room has the turbine floor raised about 10 ft. above the outside ground level, so that the basement is well lighted by windows, and the auxiliary machinery can therefore be inspected with comfort. The first generating sets installed were three of the A.E.G. manufacture, purchased second-hand with the rest of the equipment. These are each rated at 795 kw. at 3,000 r.p.m., and supply three-phase current at fifty cycles and 3,300 volts. They are of the Curtis type, and were originally guaranteed to have a steam consumption not exceeding 18·2 lb. per kilowatt-hour at full load. More recently a 2,000-kw. Curtis turbo-generator has been installed by the British Thomson-Houston Company, of Rugby. This has rotary air pumps, whereas the older machines had condensing equipment of the Edwards' type. Each turbo-generator carries an exciter on an extension of its shaft, but these are all connected to the switchboard so that they can be used in any combination desired. A Tirrell regulator automatically controls the voltage of the main generators. A view of the engine-room is given in Fig. 43, annexed. A hand-operated overhead crane facilitates the dismantling or erection of machinery. The main flue comes across underneath the engine-room floor and terminates in a handsome brick chimney carrying the initials of Messrs. Clayton and Shuttleworth.

Although this power station was entirely laid out and erected by Messrs. Clayton and Shuttleworth, and operated by them for some time, it has now been acquired by the Lincoln Corporation. When the power shortage in Lincoln became acute, the Ministry of Munitions caused an investigation to be made, and decided that rather than the corporation or any of the large manufacturers should embark on the construction of a new station it would be better for the city to acquire and enlarge that of Messrs. Clayton and Shuttleworth. Being of thoroughly modern and efficient design, and located on a site well situated as regards coal and water, and with ample room for extensions, it would form a good nucleus of a large municipal station. In accordance with this plan very large extensions are now being carried out.

The original power-house in Messrs. Clayton and Shuttleworth's works is now used as a sub-station, and is equipped with two 750-kw. rotary converters and transformers which receive three-phase current at 3,300 volts and supply it to the Stamp-End Works as direct current at 500 volts.

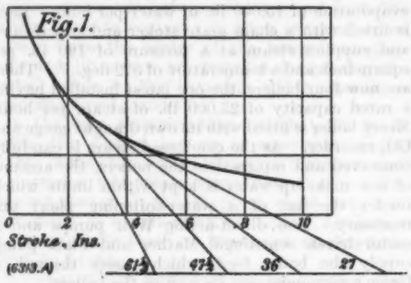
CLEARANCE IN INTERNAL-COMBUSTION ENGINES.

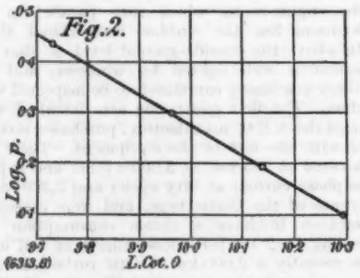
Note on a New Method of Determining the Clearance of an Internal-Combustion Engine.

By A. H. STUART.

IN commercial tests of internal-combustion engines the clearance is often calculated by assuming the exponent of the volume to be 1·3 in the equation of the compression curve of the indicator diagram (*vide* "Commercial Tests of Internal-Combustion Engines," by W. A. Tookey, Proceedings of the Institution of Mechanical Engineers, January, 1914, page 15). This method has been known to give very erroneous results in some cases where it could be checked by actual measurement (*ibid.* page 49). The following method has given excellent results on a test engine on which the above method failed.

The engine was a horizontal single-cylinder four-cycle gas engine running off the gas mains and using Lodge ignition. Diameter of cylinder





5·5 in.; stroke, 11 in.; impulses, 85 per minute; revolutions, 254 per minute.

THE METHOD.

Let

c denote the clearance, expressed in inches of the cylinder length.

v denote the number of inches of the stroke accomplished when the pressure is p.

Then:

$$p\,(v+c)^n = k$$

$$v + c = k^{\frac{1}{n}}\,p^{-\frac{1}{n}}$$

and

$$v = a\,p^{-\frac{1}{n}} - c$$

where a is a new constant.

Differentiating:

$$\frac{d\,v}{d\,p} = -\frac{a}{n}\,p^{-\left(\frac{1}{n}+1\right)}$$

This equation is independent of the clearance. Neglecting the negative direction of the line, we have:

$$\log\frac{d\,v}{d\,p} = \log\frac{a}{n} - \left(\frac{1}{n}+1\right)\log p$$

It is clear, therefore, that a graph showing the relation between $\log\frac{d\,v}{d\,p}$ and $\log.\ p$ should give a straight line.

Fig. 1 shows an enlargement of the expansion curve of an indicator diagram. At four selected points tangents have been drawn and the angles (θ) which these lines make with the horizontal measured. The co-tangents of these angles give values of $\frac{d\,v}{d\,p}$ at the points selected.

Any error of judgment in drawing these tangents would be revealed by the corresponding point standing aloof from the straight line graph which is subsequently plotted.

It may be noted that the actual value of these co-tangents will depend upon the relative scales of pressure and volume, but as we are taking out logarithms before plotting, the common factor will not influence the direction of the graph, and hence is of no importance.

The following table gives the values obtained from Fig. 1.

v.	p.	Log. p	θ.	L. Cot. θ.
1	2.70	0.4314	61½	9.7348
2	1.99	0.2989	47½	9.9621
3	1.55	0.1903	36	10.1387
4	1.25	0.0969	27	10.2928

Fig. 2 shows the graph obtained. The tangent of the angle which this graph makes with the axis of log. p is equal to the coefficient of log. p in the original equation. The value of this tangent is given by the ratio of the intercepts of the axes, viz., $\frac{6.75}{4.05} = 1{\cdot}67$.

i.e.,

$$\frac{1}{n} + 1 = 1.67$$

$$n = 1.49.$$

We now have

$$p\,(v+c)^{1\cdot49} = k$$

i.e.,

$$\log.\ p + 1.49\ \log.\ (v+c) = \log.\ k$$

substituting two known values of p and v (*e.g.*, $v=1$, $p = 2{\cdot}7$, and $v = 4$, $p = 1{\cdot}25$).

$$0.4314 + 1.49\ \log.\ (1+c) = \log.\ k$$

$$0.0969 + 1.49\ \log.\ (4+c) = \log.\ k$$

$$0.3345 = 1.49\ \{\log.\ (4+c) - \log.\ (1+c)\}$$

$$\log.\frac{4+c}{1+c} = \frac{0.3345}{1.49} = 0.224$$

$$\frac{4+c}{1+c} = 1.675.$$

$$4 + c = 1.675 + 1.675\,c$$

$$0.675\,c = 2.325$$

$$c = 3.45''$$

Bringing the piston to the inner dead centre, filling the clearance with oil and measuring the latter, the volume was found to be 80 cub. in. The clearance expressed in inches of the cylinder is therefore $\frac{80}{0.7854\,(5.5)^2} = 3{\cdot}36''$

Assuming the exponent of v to be 1·3 in the compression curve of the diagram the clearance is 2·5. This large error shows the weakness of this assumption and is explained by calculating the exponent (assuming the true clearance) which has a value of 1·48.

DEFECTS IN MOTOR VEHICLES AND THEIR REMEDY.

By F. STRICKLAND.

THE late war led to the use of motor vehicles on a scale which had never been contemplated before, and there can be no doubt that it has had an enormous effect on the employment of such vehicles in civilian life. Before the war the motor car had come into pretty general use and the motor-bus had displaced the horse omnibus almost entirely; but in the conveyance of goods the motor was only making relatively slow headway. It was undoubtedly slowly extending and eventually it would, except for certain special classes of work, have completely superseded the horse-drawn vehicle, but this change would have taken considerable time.

The war caused an enormous demand for motor transport, and wherever there were roads fit for motors to go they were used practically exclusively. The result of this will undoubtedly be that the same change will take place in road transport in peace, the horse being practically entirely abandoned, and the motor becoming the only vehicle used on the road. Further, there will be an enormous extension of road transport so that the motor will not only have to do practically all the work of this kind which used to be done by horses, but will have to do a vast amount of additional work as well.

Under these circumstances one of the principal points in the success of any particular form of motor will be the cost of upkeep in the matter of repairs. It may be taken for granted that any modern vehicle from the motor cycle to the large lorry is now reliable in the ordinary sense of the word, and will do its work without seriously breaking down. Further, a great many of them are fairly durable provided worn parts are replaced with reasonable promptitude. There are lorries and cars seven and eight years old which are still running well to-day.

Nevertheless, there can be no doubt that there is great room for improvement in the durability and cost of upkeep of all the ordinary forms of motor vehicle. The numerous advertisements for cars wanted built "not earlier than" four or five years ago, and the fact that insurance companies refuse to insure cars against mechanical breakdown if more than a few years old, show this conclusively with regard to the pleasure cars. The huge demands for spare parts during the war show it also with regard to lorries.

All new developments of machinery pass through three fairly distinct stages. First the experimental, second the practical, third the improvement of detail. We have now got to the third stage in the case of the motor, and it is time to go through the whole of the construction and eliminate defects with a view to greatly reducing the cost of upkeep. Owners have so far been content to put up with the heavy cost of upkeep which is inevitable in a more or less new development of machinery, but there is little doubt that in the future costs will be very carefully watched and those makers whose vehicles require heavy repairs will find it very difficult to sell them. The pleasure car is, of course, to a large extent influenced by fashion, and is not therefore so purely a matter of mechanics as the commercial car, but the number of so-called pleasure cars which are actually used in business is increasing very rapidly, and here costs will be the main item. A pleasure car runs so small a number of hours a day as a rule that it should last a very long time without appreciable repairs or renewals, but this standard has not been yet attained.

Whatever class of vehicles are being considered there are some principles of design which should be common to all. The cost of upkeep consists mainly of three items. First there is the repair or replacement of broken parts. This ought to become extinct as parts should be designed not to break. Second, there is the actual cost of spare parts. This should be as far as possible reduced by either making parts more durable or else making them cheaper to renew. Third, there is the cost of the necessary dissembling and assembling in order to put in replacements or make adjustments. In this cost should be included the loss of earnings during the time the vehicle is off the road. This can be reduced by making parts easily accessible. This latter point has a great effect on the question of whether it is better to make parts durable or on the other hand to make them cheap to renew. Where parts can be replaced very quickly, so that the work can be done without interfering with the ordinary use of the vehicle, it may often be better policy to make them cheap rather than durable, as in this case as a rule the first cost of the machine is reduced and often weight saved. In the case of the more inaccessible parts, however, frequent replacements mean a constant laying up of the machine with loss of earnings and often disorganisation of the business, and it will then probably be the better policy to make the details more durable unless the design can be altered so as to make them easily replaceable.

A point which might have a great deal more attention than it has at present is the matter of the supply of oversize and undersize parts for the replacement of worn ones. During the war an enormous number of perfectly good parts were scrapped when slightly worn because there was no system of over and undersize parts for making repairs. Thus when a cylinder got worn so that the piston was slack it was scrapped, although it would have been perfectly possible to grind it out and fit an oversize piston. Cylinder castings are a very expensive item and the waste in this case was very great. The same was true of many other parts.

For some time individual machines have been rebuilt by grinding out cylinders, grinding down crankshafts, &c., and making special parts of suit-

able size to fit, but it is clear that in the future the price of labour will often prevent this being done to pay on a small scale. That is to say it will not pay to put an individual crankshaft in the grinding machine to true it up and make a special set of bearings for it. What is needed is that the work should be done on a large scale.

This has been done in the case of some of the cab companies, &c., who practically re-manufacture their vehicles when they get worn. That is to say, they have standard dimensions to which all worn parts are re-ground and standard size parts to fit them. Thus in the case of crankshafts, all worn shafts may be re-ground to $\frac{10}{1,000}$ in. under size, and when they require truing-up again re-ground $\frac{20}{1,000}$ in. under size. Suitable bearings for these sizes are kept in stock. The work can then be done on repetition methods, for all worn cranks go to a machine which is kept at work grinding to one size.

It seems that the time has come when the makers of vehicles, especially commercial vehicles, should work out a complete system of replacements on these lines, and deal with the matter in a manufacturing basis. The extent to which it is desirable to repair parts, of course, depends on their nature. Thus, in the case of expensive parts, it may be desirable to re-grind them twice or even three times before scrapping them. In the case of small cheap parts, on the other hand, it may not be worth while to have any repair-standard parts at all, as it is cheaper to scrap the worn parts and replace them with others of the original standard size. This is a matter of detail, but the important point is that there should be such a system of replacements arranged in such a way that if the owner of a vehicle has a crankshaft which requires truing-up he can send it to the maker and receive in exchange one already ground to undersize at once out of stock without waiting for his own particular shaft to be dealt with. It should be far cheaper for the manufacturer to do this on a large scale than for each carrying company to do its own or to get it done in small repair shops, and hence the customer ought to greatly benefit while the maker made a profit.

A point in this connection is that as far as possible parts subject to wear should be easily replaceable, and that as far as possible expensive parts should not form wearing surfaces. This is very important, as sometimes very expensive parts have to be replaced owing to wear in a very small portion.

The principal parts which gave trouble by breakage during the war were springs, engine and gear-box arms and frames. To a certain extent these breakages were due to the rough use to which the vehicles were put to, and the nature of the roads, and they would not be so prominent in ordinary civil service. At the same time there is no doubt that there is considerable room for improvement in these respects, for although the roads were rough the speed was, in most cases, extremely slow; high speed on a moderately good road is nearly as trying as very slow speed on a bad one. Further, a very considerable number of the impressed vehicles suffered from these defects, especially broken springs, when they were received.

Breakages of springs were a very serious item, but varied very much in the different makes. The main reason for these breakages appears to be that the metal in the springs is stressed too high when the spring is compressed. The stresses in springs are, of course, of two kinds, first those which are due to the static load, and second the addition to these due to the spring being compressed when going over a bump. These stresses naturally depend on the proportions of the springs and the weight they carry. Accurate calculations of these stresses are not easy to make as it is difficult to get the exact weights of the vehicles and their loads. It is also not possible to ascertain exactly the amount a spring compresses in practice. These points can, however, be deduced approximately, and it will be found that in many cases springs are worked at very high stresses indeed, and further that generally speaking the springs which have the highest calculated stresses fail the most frequently in practice. In considering the effects of these stresses, it must be remembered that those due to the static weight of the vehicle are more or less constant, while those due to the compression of the spring when running vary every time the vehicle goes over a bump. The whole question of springing of motor vehicles is a very complex one, and is probably not capable of complete solution by theoretical methods. All that can be done by a theoretical treatment, at all events in the space available here, is to make certain suggestions, leaving the details to be settled by trial and error.

The main requirements of springs are: First, that they must carry the vehicle without breaking; second, that they must spring sufficiently to isolate it as far as possible from the road shocks; third, that they must be of reasonable weight. These three requirements are not altogether easy to satisfy.

It is, of course, quite easy to make springs which do not break as this is simply a matter of making the spring strong enough. Such springs may, however, not have enough give in them to absorb the road shocks. It is quite a common thing when springs break to simply add more leaves, and this was often done in France during the war. This, however, makes the spring stiffer and therefore, increases the shocks on the vehicle and may make these too great for efficiency. If springs break from the stresses being too high it is, however, usually possible to design other springs to take their place which will have the same amount of deflection but will carry the load at a lower stress.

In the case of pleasure-car springs, the question is complicated by the fact that at high speeds springs must have special qualities to combine comfort with stability. In order to fulfil these conditions, makers use springs of very varying proportions. Pleasure cars vary so much in weight, &c., that it is hardly possible to compare them, but the variation in the weight of the three-ton lorries is not great, so the springs of these vehicles may be taken as fairly comparable.

Formulæ for the calculation of the properties of springs vary slightly according to the assumed contour of the springs. Hence any calculations based solely on the length, breadth, number and thickness of leaves are not absolutely accurate. For purposes of comparison, however, we may take the following as giving the results near enough for the purpose:—

$$F = \frac{W \times 3 \times L}{T^2 \times N \times B}$$

$$D = \frac{F \times L^2}{M \times T}$$

where: F = stress in lbs. per square inch; W = load on spring in lbs.; L = length from spring seat to eye of shackle; T = thickness of leaves; B = breadth of spring; N = number of leaves; and M = modulus of elasticity which may be taken in round numbers as 30,000,000, dimensions being in inches.

Table I gives particulars of some front springs of three-ton lorries, and Table II particulars of some back springs. In the calculations of the stresses and deflections, the load on the front axle is taken as 4,000 lbs. and on the back axle 10,000 lbs. This is, of course, only an assumption, and the weight of the individual lorries varies slightly. The variation in the weight is, however, not very great, as the load is constant. The first seven columns in these tables give the dimensions of the springs. The next three give: (1) the static stress on the spring when at rest; (2) the stress on the spring due to a deflection of 2 in.; (3) the sum of these, being the stress in the spring when deflected 2 in. beyond the position under static load. The last column gives the deflection under the static load, and is a fair measure of the extent to which the spring will isolate the vehicle from the road shocks.

It will be seen that the different springs vary very greatly in their proportions, although designed for substantially the same work. Thus, in the case of the front springs, there are the following variations:—

Length, from	2 ft. 10 in. to 4 ft. 4 in.
Breadth, from	1¾ in. to 3 in.
No. of leaves	6 to 12
Thickness	0·278 in. to 0·376 in.
Static stress	34,500 lb. per sq. in. to 65,000 lb. per. sq. in.
Deflection under load ...	1·01 in. to 3·82 in.
Stress for 2 in. deflection	34,000 lb. to 78,000 lb.

The back springs vary somewhat less, but still the variation is very considerable. It hardly seems that such variations are justifiable, and in practice there was a very great difference in the performance of the springs, some giving a great deal more trouble than others. In some makes it was not uncommon for a column of 50 lorries to break two or three springs a day. The essential point that stands out is that the stresses are in all cases high, and in some very high, and it was found in practice that, generally speaking, those with the highest calculated stresses broke most frequently.

It will be observed that the total stress is calculated on the assumption that the spring is compressed 2 in. from the static position. This is an arbitrary assumption, as the actual movement of springs may vary, but it is hardly likely that a lorry can be driven over rough roads without the spring giving to this extent. Further, in a considerable number of cases there were buffer stops to the springs limiting the movement to about this amount.

An interesting comparison can be made between springs No. 1 and No. 2, Table I. The former gave very little trouble, while the latter was one of the worst offenders. It will be seen that the static stress in No. 2 is actually lower than No. 1. The reason for breakage is evidently that the length of the spring is too small in proportion to the thickness of the leaves, hence the stress due to deflection is very high, and the resulting total stress enormous. No. 3 had a very large number of breakages, apparently for the same reason. No. 4 is an example of a spring of the extreme opposite

TABLE I.

Ref. No.	Total Length between Eyes.	Length of Spring Seat.	Effective Length = L.	Breadth.	Depth.	No. of Leaves.	Mean Thickness.	Static Stress.	Stress for 2-In. Deflection.	Total Stress, 2-In. Deflection from Static Position.	Deflection under Static Load.
	ft. in.	in.	in.	in.	in.		in.				in.
1	3 11	4¼	20¼	2½	2½	9	0·321	53,000	40,000	93,000	2·65
2	3 0	4	16	3	2	6	0·333	48,000	78,000	126,000	1·23
3	3 2½	6½	16½	2½	2½	9	0·365	46,000	70,500	116,500	1·31
4	4 4	4½	23½	1½	3½	12	0·313	65,000	34,000	99,000	3·82
5	2 10	4½	15½	2½	3½	11	0·296	40,000	76,000	116,000	1·05
6	4 0	5½	21½	3	2½	9	0·278	61,000	37,000	98,000	3·8
7	3 6	5½	18½	2½	3½	9	0·376	34,500	67,000	101,500	1·01
8	3 4	5½	17½	3	3	11	0·278	42,000	55,000	97,000	1·53
					TABLE II.						
9	4 6	7½	23½	3	5½	13	0·404	55,000	46,000	101,000	2·4
10	3 6	5½	18½	3	4½	13	0·346	59,000	61,500	120,500	1·94
11	3 9	7	19	3	4	11	0·363	65,000	60,500	125,500	2·15
12	5 0	6	27	2½	5½	12	0·438	64,000	36,000	100,000	3·55
13	4 4	8	22	3½	5	13	0·384	49,000	47,500	96,000	2·07
14	4 8	4½	25½	2½	6½	13	0·518	46,500	47,000	93,500	1·98
15	4 6	8	22	2½	6½	13	0·520	36,000	59,000	95,000	1·22
16	4 10	7	25½	2½	5½	13	0·422	73,000	39,000	112,000	3·74
17	4 5	7	23	3	6	17	0·353	54,000	40,000	94,000	2·7
					TABLE III.						
18	3 10	4	21	3	2·66	8	0·333	47,000	45,000	92,000	2·06
19	3 0	4	18	3	2·82	12	0·246	48,000	57,000	105,000	1·68

UNIVERSAL MILLING AND SHAPING MACHINE FOR PRECISION WORK.

CONSTRUCTED BY MESSRS. T. COOK AND SONS, LIMITED, ENGINEERS, YORK.

(*For Description, see opposite Page.*)

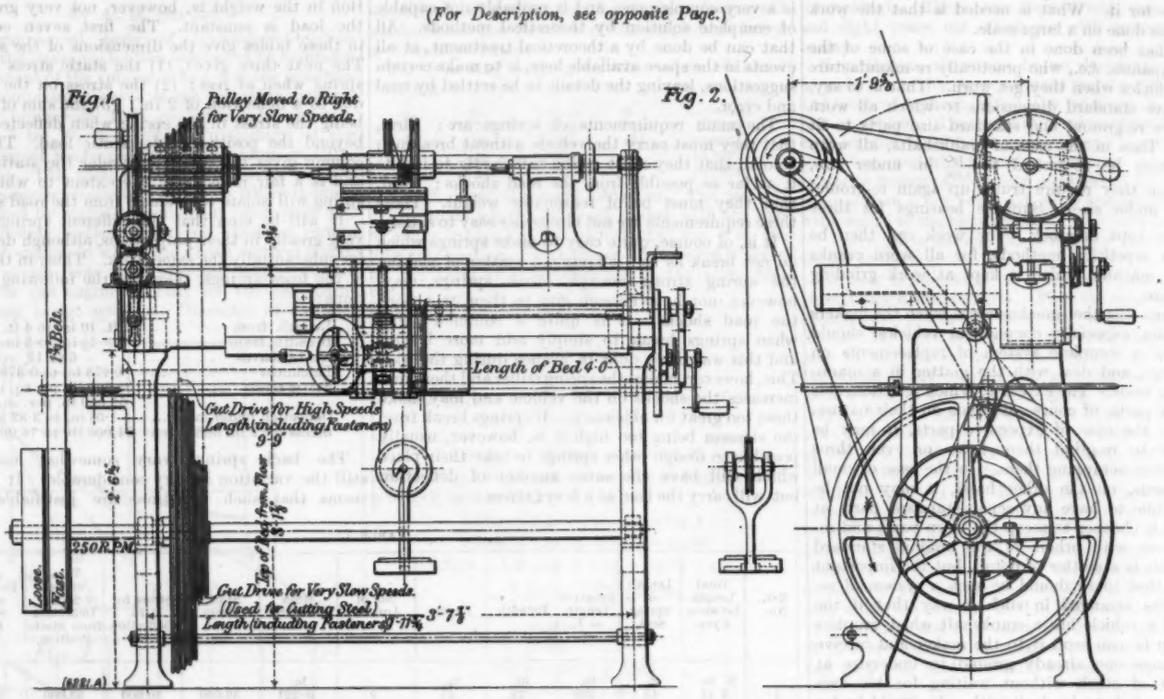


Fig. 1.
Pulley Moved to Right for Very Slow Speeds.
¾ Belt.
Length of Bed 4'0"
Gut Drive for High Speeds Length (including Fasteners) 3'3"
Top of Bed from Floor 3'1½"
2'6½"
250 R.P.M.
Loose.
Fast.
Gut Drive for Very Slow Speeds. (Used for Cutting Steel) Length (including Fasteners) 3'7¾"
Fig. 2.
1'9⅝"

characteristics, the static stress being very high indeed, but the spring very long and flexible. This spring broke a considerable number of top leaves, possibly owing to its being very narrow. It must be remembered that the whole of the drive of the axle is usually taken by the top leaf only. Had this spring been made a little broader, the length and thickness of the leaves remaining the same, the static stress would have been reduced, the top leaf strengthened, and the additional stress due to deflection would have remained the same. It would probably then have been quite satisfactory.

From a consideration of the breakages of springs, it appears that if the following conditions are observed the springs should be practically free from breakage: (1) A static stress under load not exceeding 45,000 lbs.; (2) a deflection under static load of at least 2 ins., and preferably 3 in.; (3) spring buffer stops to limit the deflection from fully loaded static position to such an extent that the total stress under full deflection does not exceed 90,000 lbs. These conditions would often entail somewhat heavier and more expensive springs than are now fitted, but would probably not only ensure freedom from spring breakage, but also generally easier riding and less wear and tear on the vehicle. The deflection of a spring working at a given static stress is as $\frac{L^2}{T}$. We can, therefore, always increase the deflection for a given stress by increasing the length or reducing the thickness of leaves; the number or breadth being increased as necessary to keep to the static stress desired. To see the effects of this we may take the springs in Table III, showing the alterations necessary in No. 2, Table I, to increase the deflection to 2 in. without increasing the static stress.

No. 18 shows how this can be done by increasing the length, the breadth and thickness of the leaves remaining the same. By making the spring 8 in. longer, and increasing the number of leaves from six to eight, the deflection is increased from 1·23 to 2·08, and the total stress at 2 in. deflection from static position is reduced from 126,000 lbs. per square inch to 92,000 lbs. per square inch. This would require the front of the vehicle to be altered, but it would be possible to increase the deflection very considerably and yet make a spring of the

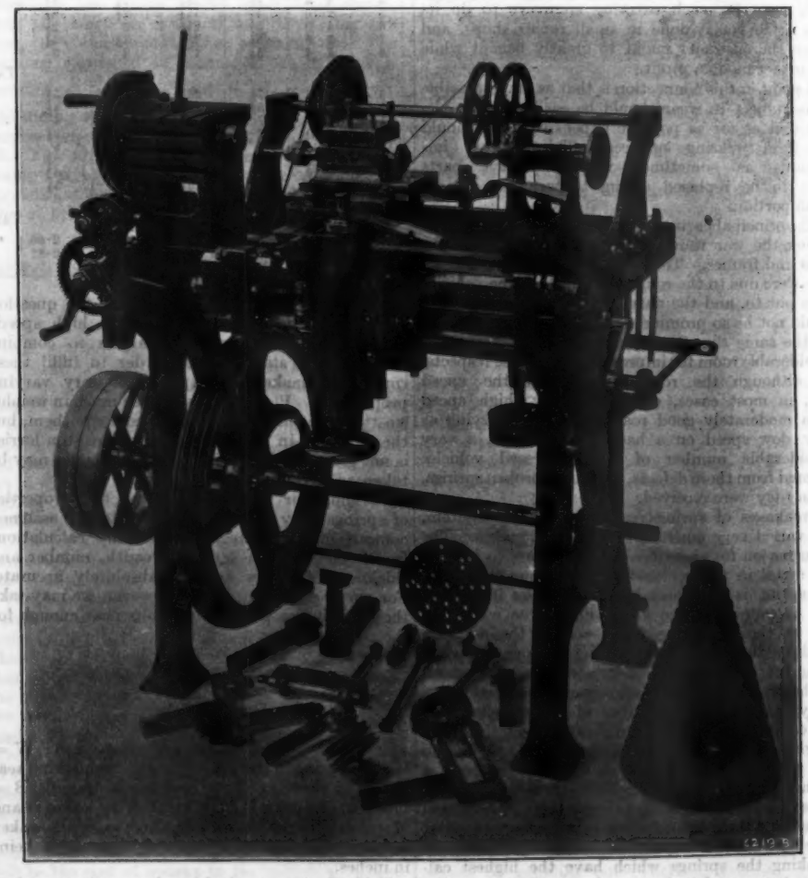


FIG. 3.

same length and breadth and, therefore, interchangeable with existing springs, without alteration to the vehicle. To do this the thickness of the leaves must be reduced, and the number increased. Theoretically, it would be possible to get 2 in. deflection by having 16 leaves 0·205 in. thick. Such a spring would, however, probably not be a practical success. It would, however, be quite practical to use a spring as No. 19, and the very great reduction of stress would, presumably, greatly reduce the breakages, while the increased deflection 1·68 in. in place of 1·23 in. would reduce the wear and tear on the lorry. Seeing the very great expense of supplying spares, it seems a pity that this matter was not gone into very much more thoroughly at the time in place of supplying huge numbers of springs of patterns known to break or simply adding leaves which had the effect of reducing the deflection of springs in which it was already too small.

It appears, therefore, that the requirements of springs include the provision of sufficient length and the use in their construction of leaves thin enough to give a good deflection combined with the strength necessary to ensure a moderate static stress. The longer the spring the easier these requirements are to combine.

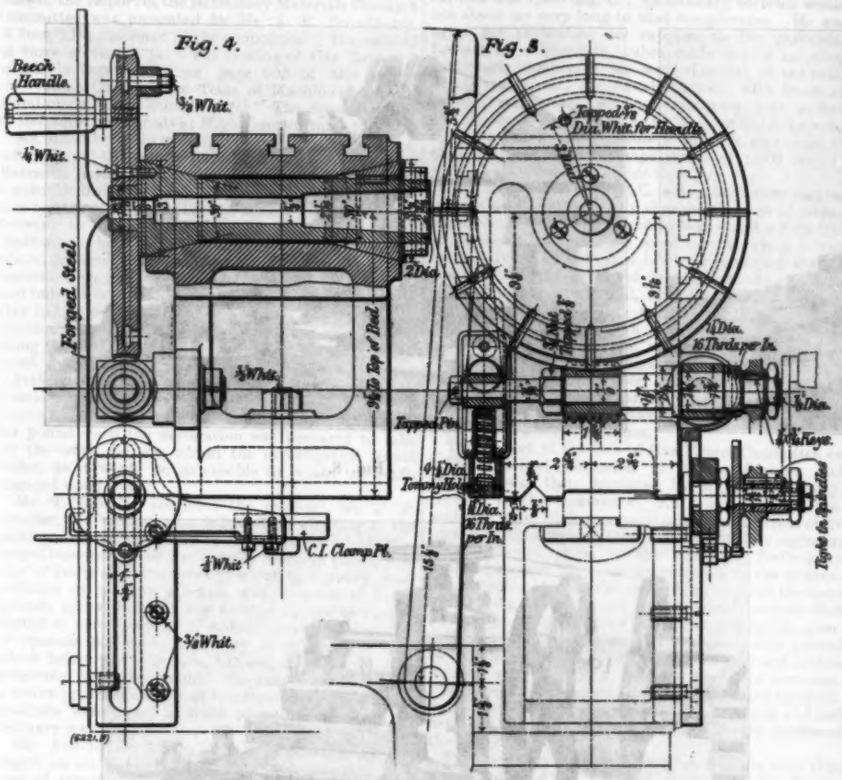
Excessively long springs have inconveniences, however, and theoretically the same result can be got in a short spring with thin leaves. The number of the leaves, again, is limited by practical considerations, one of which is that the internal friction between the leaves of a very deep spring of thin leaves may become excessive. We can, however, get the same result by making the spring broader in place of increasing the number of leaves, and it is questionable whether it would not be an advantage to very considerably increase the width. There may be difficulties with very excessively broad springs in one piece owing to torsion stresses, but in this case there is no reason why a broad spring should not be made of two narrow breadths. It is noticeable that some of the French lorries which were driven very hard over rough ground without apparent damage had springs 6 in. wide.

What has been said about lorry springs applies in principle equally to car springs. Here the deflection under static load varies even more than in lorries, the variation in 10 different patterns of service cars being from 0·47 in. to 2·8 in. in the front springs, and from 0·94 in. to 7·1 in. in the back. The lowest deflection in both front and back is in one of the two-seated light cars, while the highest deflection is in a car of the very highest class, notorious for easy riding and reliability. This shows that the very rough riding for which the light cars are notorious is not due to their lightness, but to badly proportioned springs.

(To be continued.)

UNIVERSAL MILLING AND SHAPING MACHINE.

CONSTRUCTED BY MESSRS. T. COOKE AND SONS, LIMITED, ENGINEERS, YORK.



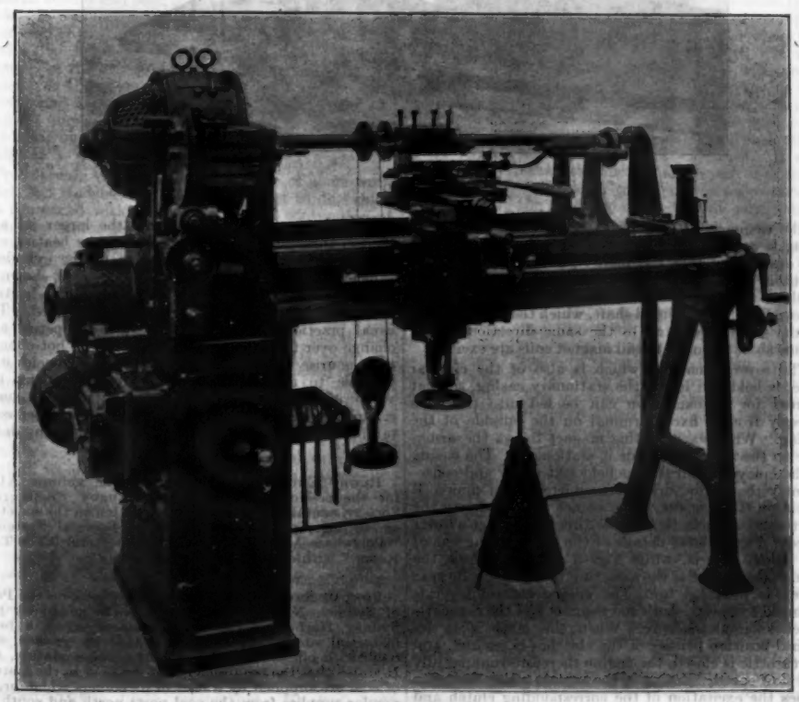


FIG. 6.

The machine is described as a universal milling and shaping machine and it will shape, slot, drill, divide and cut gears. Of the models illustrated, the first (Figs. 1 to 3) will be seen to be belt-driven, while the second (Fig. 6) is electrically driven. The first machine consists of a bed mounted on two A frame legs, which carry the driving shaft, belt driven off the line shafting. This flywheel shaft has a fast and loose pulley and striking gear is arranged at the end of the bed. The flywheel-pulley drives a back shaft by gut-belts, this shaft furnishing the motion to the milling cutter or other rotary tool used. The bed, 3½ ft. long, has planed faces on the top and in front. At the left hand end is a fast headstock of which drawings to an enlarged scale are given in Figs. 4 and 5, annexed. This headstock can be used as a work table. As shown in Fig. 6, it is box shaped, and both on the sides and top is furnished with T-slots for bolting down work. The mandril is hollow and fitted in taper draw-in collets. The dividing gear is clearly illustrated in Figs. 4 and 5, a set of 12 gear wheels being provided. The worm can be thrown out of gear with the worm wheel, which can then be turned by means of a handle. To put the worm out of gear it is depressed by throwing over a small lever. The worm is carried in front in a pivoted bearing.

The bed is fitted with a guide screw which has dividing gear at the tailstock end. This screw works a compound slide rest along the bed. The slide has vertical adjustment so that the cutting tool can be raised to any height required. The tool post has hand

A SMALL machine tool capable of performing a large variety of work is of considerable value in many branches of lighter engineering such as the making of scientific and optical instruments, gun-sights, &c. We illustrate in Figs. 1 to 9, on the opposite and present pages, and page 786, a machine of this character which is designed and constructed by Messrs. T. Cooke and Sons, Limited, Buckingham Works, York, and which is used to a large extent by that firm in their own workshops.

UNIVERSAL MILLING AND SHAPING MACHINE FOR PRECISION WORK.

CONSTRUCTED BY MESSRS. T. COOKE AND SONS, LIMITED, ENGINEERS, YORK.

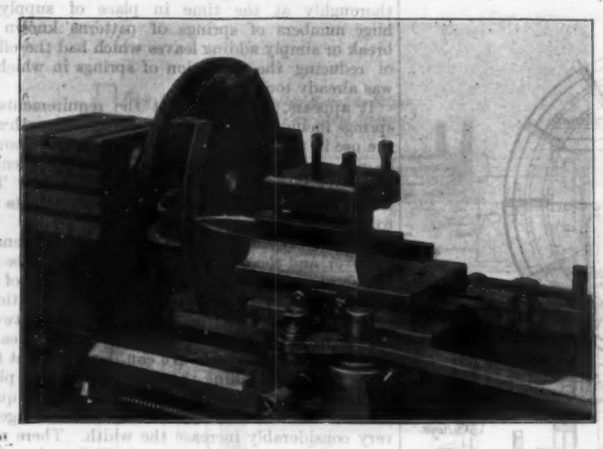


FIG. 7.

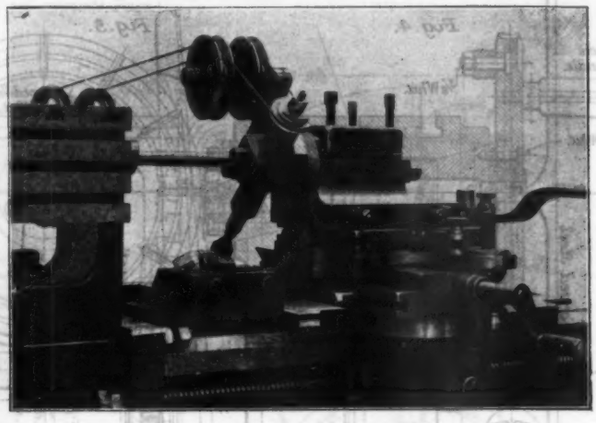


FIG. 8.

screw traverse across the machine bed, and can also be traversed by lever in both directions for slotting operations. The slide can be moved to any horizontal angle and clamped.

We have already pointed out that work may be attached to either the sides or top of the fast headstock. It may also be fixed, of course, to the mandril or to a face plate. It can further be fixed on the horizontal bed of the machine, or may be swung between 9 in. centres. It will be evident, therefore, that work can be done on a large variety of jobs. In Fig. 7 to 9, annexed, we give three illustrations of typical operations, the possibilities in this direction being too numerous for us to give more than a general idea of the utility of the tool. Fig. 7 shows a dividing job, cutting gradations with a V-shaped tool, the spacing being indexed by means of the worm and wheel gear on the headstock, already referred to. The movement of the tool in this case is the shaping action obtained by hand lever and slide. Fig. 8 shows a bit of angular milling for small bevel slides. The milling tool, a drill ground to form an end mill, is carried in a holder which is capable of being set at any desired angle (an index scale being provided) and driven from the back-shaft. The belt runs over two guide pulleys carried by an arm held by the tool rest. Fig. 9 shows a gear cutting frame mounted on the tool slide, and driven off the back shaft. We may add that small pieces of almost any shape may be machined by milling cutters of the usual forms. Division plates can be drilled and the holes drilled at any angle. Fine-toothed racks, pinions and small spurs, bevel and worm wheels can be cut. The machine can be further used for profiling, cutting spirals, scale cutting and so on. As it is intended for use on precision work the workmanship of the machine is naturally of excellent quality.

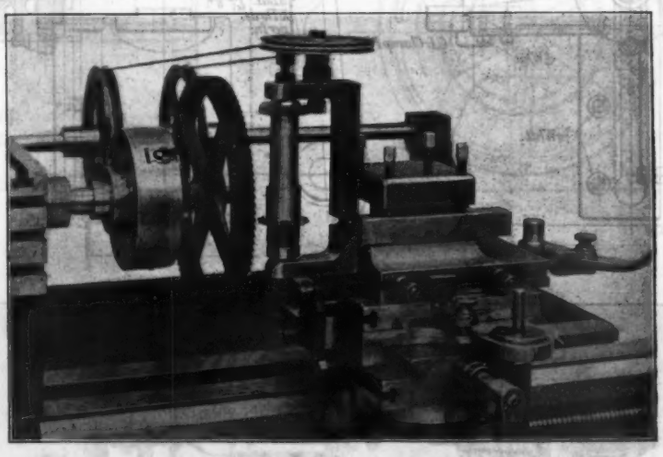


FIG. 9.

MAGNETIC REVERSE GEAR AND PETROL-PARAFFIN CARBURETTOR.

A TYPE of electrically-operated reverse gear for motor boats, constructed by the Wolseley Motors Limited, of Adderley Park, Birmingham, is illustrated on Plate XLVII, accompanying this issue, together with a petrol-paraffin carburettor designed by the same company. Referring to Fig. 1, which shows a section through the clutch and differential gear-box, the principles of construction will be evident. The drive from the engine is transmitted by means of the half-coupling A to the left-hand shaft. Keyed to this shaft is a flange to the outer rim of which is bolted the circular "ahead" magnet, so that this magnet always revolves with the engine shaft. Current for the excitation of the magnet is led to the coils by means of a stiff conductor from an insulated terminal on the shaft, this terminal being connected by another conductor passing inside the shaft to a second terminal which, in turn, is connected to a slip ring surrounding the shaft and located between the two ball bearings as shown in the illustration. An external terminal on the outside of the bearing casing is connected to a brush which rubs on the slip ring mentioned.

The excitation of the ahead magnet causes it to attract and drive the flat circular steel armature immediately behind it, and this armature in turn drives the casing of the epicyclic gear by means of extensions of the casing bolts as shown. The pinion marked B, being keyed to the shaft, rotates at the same speed as the casing and thus the planet-pinions do not rotate on their axes, but a "solid" drive through the gear teeth to the pinion C is obtained. This latter pinion is keyed to the right-hand shaft, which therefore rotates at the same speed and in the same direction as the engine shaft when the ahead magnet coils are excited.

The reverse magnet, which is also of the circular type, is held fast inside the stationary casing, so that current for its excitation can be led into the coils directly from a fixed terminal on the outside of the casing. When excited, this magnet draws the armature to the right and holds it stationary. The casing of the epicyclic gear is thus held stationary and consequently the engine drive, transmitted from pinion B to pinion C by means of the planet wheels, drives the right-hand shaft in the reverse direction and at a lower speed. Fig. 2 shows details of the pin carrying one of the planet wheels, while Fig. 3 illustrates how the spring attachment of the armature to the epicyclic gear casing is provided for. The engine control lever is arranged to operate both the throttle and the magnetic clutches simultaneously. When the lever is in its central position neither of the clutches is excited, and the throttle is closed, the engine therefore running idly at a slow speed. Motion of the lever in either direction causes the excitation of the corresponding clutch and at the same time opens the throttle.

Figs. 4, 5 and 6 show the arrangement of the petrol-paraffin carburettor. The float chamber is of the ordinary form, and either petrol or paraffin is admitted to it by means of the needle-valve, according to the position of a two-way cock. There are separate jets for the two fuels, the appropriate one being connected to the float chamber according to fuel in use. When using paraffin the oil issues from the larger jet and thence, through the throttle valve to the heating coil located in the exhaust pipe and so to the cylinders. When petrol is being used, the sliding valve, shown in section in Fig. 4 is moved so as to isolate the heating coil, which in such circumstances is not required. The usual practice, of course, is to start on petrol and change over to paraffin when the engine is hot enough to vapourise the heavier fuel, but in emergencies it is possible to start on paraffin by first heating the vapourising coil by means of a blow lamp. A small removable door covering a hole in the chamber containing the vapourising coil permits of this being done.

RUGBY ENGINEERING SOCIETY.—The volume XIII, for the session 1918–19, of the Rugby Engineering Society, contains, apart from information on the society's proceedings, papers entitled "The Decimal System," "Polyphase A.C. Commutator Motors," and "The Tool Room," with discussions thereon.

PORT OF SYDNEY.—The official handbook on the Port of Sydney, N.S.W., for 1919, recently issued by the Sydney Harbour Trust Commissioners, gives a brief historical survey of the port and of its growth, the facilities it offers, its trade, docking accommodation, &c. It states that the requirements of the port in the matter of coal are supplied by a fleet of 32 colliers which bring regular supplies from the coal ports north and south of Sydney, and for bunkering purposes usually discharge direct into the ocean-going vessels. There are 16 hulks in constant use for bunkering purposes. Among the industries of the port is that of the Sydney Harbour Colliery Company, Limited, which had many difficulties to overcome in winning coal from under Sydney Harbour. Other interesting information is given as to rates, dues, &c. The book is admirably illustrated, and contains a number of clear maps and plans.

THE INSTITUTION OF GAS ENGINEERS.

(*Continued from page 764.*)

AFTER the annual report of the council had been passed, the Report of the Refractory Materials Research Committee was presented by Mr. A. E. Broadberry, M.Inst.C.E., chairman of the committee. It consisted of three sections: (*a*) "The Casting of Gas Retorts," which is reproduced on page 803 of this issue; (*b*) "Some Comparative Tests of Machine-made and Hand-made Silica Bricks"; (*c*) "The Specific Heats of Refractory Materials at High Temperatures."

Mr. Broadberry, in moving the adoption of the report, referred to the newly-formed British Refractories Research Association, and thought the Institution as a scientific body was likely to have very good representation on its council, and that the association was looking forward to taking full advantage of the work the Institution had done. The Institution had been placed in some difficulty during the past year by the uncertain position of the new Research Association, and unfortunately their friends of the Society of British Gas Industries seemed also to be in a very uncertain position, as they did not know to what extent they were going to be compelled to come under the new Government Associations, and therefore had been hesitating a little in their support of the Institution Committee. Unless the society could see its way to continue its support and the Privy Council went on to provide pound for pound until the association was prepared to take up the work, he was afraid the investigation would suffer, as it would be impossible to retain the staffs engaged upon them.

Mr. T. Goulden seconded the motion. Mr. J. P. Leather, of Burnley, who followed, in alluding to the casting process, said that to see a fireclay which contained less water than was usually found in plastic fireclay of fairly good consistency, which by the very small addition of sodium silicate, was capable of being poured, and a retort or any fireclay apparatus cast as though it were a casting of molten metal, was a matter of extreme interest. In a very short time the slip, which before was so mobile, had set, and was ready for removing from the mould. An examination of such a retort proved that it was homogeneous, and that its qualities were equal at least to retorts made in the ordinary way.

Sir Arthur Duckham, K.C.B., speaking on the report on silica bricks, said that with the very high cost of material and labour to-day it was far more essential than it had been to get an absolutely first-class brick. It was essential that the research work should go on and that the Institution should do all that was possible to help it. The knowledge of the manufacturer, of the constructor and of the user should be pooled. If these could have a joint meeting and hold a discussion on the firebrick question, which was the essential question to-day, he thought, it would be of very great value, and any movement in that direction he should be pleased to help.

Professor J. W. Cobb, C.B.E., spoke of some work which Mr. Hodsman and he had set out to do, which was concerned with the expansion and contraction of refractory materials, about which there was so little information. A fair amount was known of what was called the permanent contraction or expansion—the shrinkage which the brick underwent or the expansion which took place—when dealing with silica bricks on heating. That measurement could be made when the brickwork had been drawn out, and it was found that it had contracted or expanded permanently so much, but in actual operation there was superimposed on this contraction or expansion a reversible which could not be measured when the bricks were drawn cold. What they had been concerned with had been the measurement of the reversible expansion and contraction of refractory materials, and some of the results they had obtained were of very considerable interest, especially as showing the peculiar behaviour of silica. The curious phenomenon which silica showed was that of giving enormous expansion between 500 deg. and 600 deg. C. and an almost complete absence of either contraction or expansion at anything above that temperature. That had an obvious bearing on the safety or otherwise of silica brick structures at different temperatures. Bricks rich in Silica, silicious bricks, behaved in almost the same way as pure silica itself.

Mr. W. N. Booth (Royal Arsenal, Woolwich) remarked that in his experience the increased life that could be got out of refractory materials used in retort construction was quite astonishing. He had had retorts for 700 days which were almost as good as when they started. He was particularly interested in the actual thermal conductivity of refractory materials and the way the conductors altered with the temperature at which these refractories were working. It was becoming increasingly important to be able, especially in industrial furnace work, to develop much higher temperatures than were ordinarily provided for by the ordinary firebrick manufacturer. He was now engaged on constructing 18 furnaces of a large size. He found that the temperature at which the metal was poured from the crucible was 1,350 deg. C., and his estimate of the actual temperature inside the furnace was 1,600 deg. C.; an ordinary firebrick would not stand up very long to that temperature. He was using for preheating air supplies to the particular furnace he referred to, tubes made out of an alloy containing roughly, 60 per cent. of nickel, 25 per cent. of chromium, and the remainder iron, with traces of carbon, manganese, &c.—an extremely high nickel-chrome steel—and it had a thermal conductivity some 50 times as high as an ordinary firebrick, and could be made to stand up to temperatures of 1,000 deg. C. with a thickness of not more than ¼ in.

Mr. F. J. Bywater, M.C. said the retort casting process would undoubtedly cheapen the cost of manufacture. Retorts which used to take about a fortnight to go through the drying could now be dried in two hours. In regard to silica brick he remarked that at one time he had very great doubt about the efficiency of machine-made material, but the investigation had shown that the machine-made brick had immense advantages over the rough home-made brick. As to thermal efficiency, it was not possible to get high temperatures through refractory material without enormously increasing the fuel consumption. He hoped the day was not far off when it would not be necessary to interpose between the coal and the gas a highly refractory substance.

The Report of the Life of Gas Meters Committee on "The Internal Corrosion of Mains, Services and Meters," was then presented by Mr. J. G. Taplay, chemist to the committee. An interim report, presented in May, 1919, was based on an examination of 26 corrosion deposits and liquors, contributed by engineers from different parts of the country. Preliminary conclusions were given having reference to the destructive influence of hydrocyanic acid in the gas in the cases of undertakings which did not completely remove that impurity. In other cases salts produced by the interaction of ammonia and carbon bisulphide were proved to be almost equally harmful, while oxygen and carbon dioxide were referred to as lesser agents of corrosion. The presence of moisture was in all those cases essential. Subsequently 40 further samples came to hand and had been analysed. The general results merely confirmed the previous conclusions.

Representative cases of corrosion deposits were then given, followed by analyses of some of the liquors received, and of samples of purification oxide taken from "catch" boxes. One of the worst reported examples of corrosion had been that of a station meter where the metal parts had been very badly attacked. It was possible that such corrosion might be more widespread than was known, for the reason that leakage in the drum of a works meter caused slowness of registration, and if there were trouble in equal degree with consumers' meters, the two errors would cancel each other so far as unaccounted-for gas was concerned. It was said, however, that the measuring drums of station meters quickly failed after corrosion had once started. On comparing the corrosion deposits with purification oxide it would be observed that peat was absent from the former and, generally speaking, that ferric ferro cyanide was in less quantity in the latter. Also in the case of corrosion deposits, the oxide of iron was highly magnetic, whereas purification oxides, especially those from the "catch" purifiers, were either only very slightly magnetic, or not at all. The sulphur per cent. in the corrosion deposits might be produced from sulphuretted hydrogen in the distributing system, owing either to the imperfect removal of the latter or to the interaction of carbon bisulphide and ammonia, This impurity (SH_2) had a direct action on metallic iron and on any iron rust present, forming sulphide of iron. The oxygen in the gas revivified the iron sulphide, and sulphur in the free state was deposited.

Experiments had been made in coating the interior of services with protective paints, and so far as preventing the action of the corrosive agents was concerned, the result was all that could be desired. Unfortunately, however, the paints were invariably dissolved by benzol, &c., present in the gas, or even by petroleum vapour. As to galvanising experiments made by passing gas containing hydrocyanic acid, carbon bisulphide, ammonia, &c., through a galvanised wrought-iron pipe produced corrosion quickly, and in a very marked degree. If tinning the iron pipe were commercially possible there would be much to recommend that form of protection. Experiments had been made with three different metals proposed for use in the manufacture of dry gas meters: (*a*) Lead coated iron, (*b*) aluminium, (*c*) an alloy submitted by Mr. T. Glover, of Edmonton. So far as hydrocyanic acid plus ammonia plus moisture were concerned, all three metals were unaffected. The same result applied to oxygen and carbon dioxide and moisture, but with carbon bisulphide plus ammonia plus moisture, the products of the interaction of those affected the metals as follows: (*a*) Sulphide of lead was formed on the surface of the metal, but unless something occurred to remove it, it would form a protective coating against further corrosion; (*b*) no action whatever; (*c*) similar to (*a*) but in much less degree.

The report stated in conclusion that it was evident that, with the exception of hydrocyanic acid, the various corrosive agents that had been mentioned as present in coal gas were well within the possibility of control or removal in a more or less complete degree. For the elimination of hydrocyanic acid there was still lacking a simple process suitable for adoption by the smaller gas undertakings, and in that direction experiments were proceeding.

In the discussion, Mr. F. G. Cockey (London) said he could not help thinking the report had brought the members a great deal nearer to the point at which they would be able to bring down the price of gas considerably. The question seemed to resolve itself into one of expense. How much could they afford to spend in increased purification, washing and condensing of the gas?—and on the part of meter makers what could be done in the way of making the meters more resistent to corrosion? Mr. T. Glover (Edmonton) remarked that if the conditions under which gas engineers had been working in the past two years could be got over and it was possible to do away with traces of cyanogen compounds, sulphur compounds in some cases, and even ammonia, he did not think there need be much fear in the future with regard to corrosion. Mr. Glover also referred to the work of the committee in regard to the desired revision of the Sales of Gas Act. Mr. H. Townsend (Wakefield) gave some interesting particulars of the results he had obtained by introducing in his district the methods for spraying gas meters which had been described in the committee's previous report. He had made use of the microscope in connection with an investigation on the subject which he had conducted at Wakefield. Naphthalene troubles had arisen and had been overcome. Mr. T. Goodwin (London) said the main point arising from the report was that ammonia must be kept out of the gas as much as possible, and that the carbonic acid and the oxygen should be kept down. Apart from the corrosion of the meters by the hydrocyanic acid formed, it must not be forgotten that carbon bisulphide and ammonia interacted to give off sulphuretted hydrogen, which was very objectionable in the mains. As to the corrosion of mains, it was necessary to bear in mind that the gas was now dryer than it used to be. The mains, therefore, tended to become oxidised by oxygen and by carbonic acid that went forward. For that reason he strongly deprecated complete extraction of the benzole from the gas, as being very dangerous, unless any hydrocarbons that were taken out were either replaced by oils sprayed into the mains, or other means of that sort were adopted. If the mains and the interior of the meters could only be coated by spraying it could act as a most proficient prevention of corrosion of every form.

The last communication considered on the first day of the meeting was the report of the Institution Gas Research Fellowship on "Some High-Temperature Reactions of Toluene and Benzene," by Dr. S. F. Dufton and Professor J. W. Cobb. In presenting it, Professor Cobb stated that the work might be regarded as a part of the study of the influence of red-hot coke and radiant heat on volatile productions of carbonisation, which was commenced in 1913 and formed the subject-matter of a report under the head of the Gas Research Fellowship (Hollings and Cobb) in 1914. Some of the preliminaries of the work now reported on were carried through by Mr. W. Gibson, who was granted a war bursary for the purpose by the Royal Society War Committee. The treatise showed that benzene passed through a heated column of coke with a time of contact of about 12 seconds, began to undergo molecular condensation in an inert gas at about 500 deg. C. with elimination of hydrogen, the first product being diphenyl. At 750 deg. the action was much more extensive and more complex, as, in addition, compounds such as diphenyl benzene were formed. All seemed to be saturated compounds. At 920 deg. free carbon was produced also in quantity.

On the following morning, after the annual meeting of the Institution's Benevolent Fund, the third and fourth reports of the Gas Investigation Committee were taken, both of them of great value. Abstracts were given by the respective research chemists, Mr. James W. Wood, M.Sc., and Mr. A. Parker, D.Sc. The third report described the continued experiments carried out at Birmingham on the relative efficiencies in use of different grades and compositions of gas; the fourth report, those at Uddingston on the comparative economies in production of different grades of gas. Mr. Wood had examined the effects produced by the direct addition of nitrogen, carbon dioxide, and air to coal gas, in order to secure more precise information than had hitherto been available on the influence of inert constituents. The results obtained had already proved of service in the conferences with Sir George Beilby and the Fuel Research Board which preceded

the issue of recommendations to the Board of Trade on new statutory regulations for public gas supply. Numerous tests carried out by Mr. Wood on coal gas lowered in calorific value by the addition of inerts, or by admixture with water gas, had made it possible to state the influence of such additions or admixture more precisely than had ever been possible before. A large number of tests had been made with the upright incandescent mantle burner as being a use for gas well calculated to display differences in efficiency and behaviour. It was known from preliminary experiments that, in the use of gas for heating, the relative importance of which was increasing so rapidly, the difference in behaviour between gases of different calorific values and compositions was very much less marked. This point had been brought out again very clearly by a series of experiments which Mr. Wood had carried out on the behaviour of different gases in a gas fire. They showed that, excepting for rich gases (requiring a large volume of air per cubic foot for their complete combustion) the addition of air down to 350 British thermal units gross per cubic foot produces no determinate effect upon the radiant efficiency in use (and hence presumably upon the total thermal efficiency also). Nitrogen might be added to good coal gas to the extent of 20 per cent., thereby reducing the calorific value to 500 British thermal units gross, without affecting the radiant efficiency to any measureable extent.

In the fourth report it was pointed out that one installation at Uddingston on which the research was carried out, was erected for the purpose of manufacturing gas for town's supply and not as a research station. It was consequently necessary to spend considerable time on preliminary work, such as fitting up and calibrating apparatus required. A full setting of eight vertical retorts were used in each test, and no other retorts in the works were allowed to be in operation at the same time. The make of gas per day varied considerably. The methods of measuring the coal, coke, tar, liquor, gas, fuel to heat setting, and steam to retorts were described, as were also those adopted in the measurement of temperatures, pressures, &c. Plant routine and details of the tests followed, and a lengthy discussion of the bearing of the water gas and steam carbon equilibriar on the results of the tests was entered upon. The thermal analysis of carbonisation was then dealt with, three sources of heat being considered: (1) Heat supplied as fuel to heat the setting either in the form of coke to the producer or as purified coal gas; (2) fuel required to raise the steam passed into the retorts, these figures being calculated on the basis of a 70 per cent. boiler efficiency; and (3) the sum of the amounts of heat liberated in the formation of new compounds produced in the distillation of the coal; this included the heat of formation of the water produced in the distillation.

The next points considered were the distribution of carbon, nitrogen and sulphur, and the evaluation of the tar and composition of liquor. Then followed sections on oil-washing experiments and complete gasification, concluding with appendices on the following methods of calibration of tar and liquor tanks, station meter, steam nozzles and coke skip; methods of analyses of coal, coke, tar and ashes; of crude gas direct from retorts; crude gas outlet purifying machine; purified gas, producing gas and waste gas; solutions for gas analysis; calibration of apparatus; analysis of ammoniacal liquor; benzene and toluene in coal gas; and evaluation of tar. In a series of tables, I to XII, the results were recorded. The thermal efficiency of carbonisation air test A was shown to be 67·7 per cent., and the thermal efficiencies of gas production 57·8 per cent.

Professor Cobb, in introducing the reports, expressed the committee's acknowledgments of the help rendered by the Uddingston Gas Company and their engineer, Mr. L. Hislop; and by the Birmingham Corporation Gas Committee and its chief chemist, Dr. E. W. Smith. Facilities for further work had been offered by Mr. T. Glover at the Norwich gas works, Mr. J. Bond at Southport, and Mr. Shapley at Leeds.

The president read a letter he had received from Sir George Beilby, in which he stated that the Fuel Research Board were engaged at their research station on a careful study of the data which were at the foundation of steaming in vertical retorts. They hoped within the next few months to be able to discuss the results with the Institution's Committee. Sir Dugald Clerk went on to say that the present average rate of thermal efficiency in use appeared to be something like 42 per cent. and he saw no particular reason why it should not be raised to at least about 60 per cent. on an average. The efficiencies in the report were taken by the method suggested in the Clerk, Smithells and Cobb report, i.e., to load the gas production with the total heat loss, the object being to consider the gas as the product and the others as by-products. There were arguments for giving a higher efficiency ratio in connection with the tar and even the coke, but all those concerned thought that was the only safe method to adopt. It would be seen that the efficiencies on that basis rose from 54·37, *i.e.*, the efficiency of production of the gas, to 62. Then an increased steaming produced a fall, and in the next experiment the efficiency of gas production had fallen to 58·56. All through the efficiency of carbonisation was falling, and it fell still further when they came to complete gasification. The efficiency of carbonisation had fallen in that particular apparatus from 83·18 for straight gas to 67·7. If they completely gasified with that system, instead of conserving the fuel resources of the country they would deplete them to the extent of the difference between 83 and 68. The highest efficiencies were obtained at a moderate steaming.

Mr. T. Glover (Norwich) referred to the important work which had been done by the committee in association with the Leeds University; the establishment there of a Livesey professorship in memory of Sir George Livesey, had been amply justified. After some remarks on inerts and temperatures, Mr. Glover, alluding to the nitrogen balance, said it would have been interesting if the coal, which appeared to give very high nitrogen and ammonia results, had been compared in parallel columns with the coals from other districts. Those who had taken a theoretical interest in the development of the vertical retort had always based their hopes on the fact that the recovery of nitrogen would be very much greater in the vertical than in the horizontal retort.

Mr. W. J. Smith (Bolton) said he had been wondering why the temperature in the combustion flue should be lower for the fifth test than for the first—whether it was due to the capacity of the plant or whether the experimenters thought it wise to work with a lower temperature. Mr. Glover had spoken about increasing the ammonia; and he (Mr. Smith) also wished to have the CO_2 removed.

Mr. W. M. Valon (Stafford) gave some interesting particulars of his experience of the working of vertical retorts at Stafford: the make per ton worked out at 18,370 cub. ft. with coke for sale of 8·12 cwt.; the tar was 17·54 gallons; the calorific value of the gas 471 British thermal units; the total inerts 9·2, consisting of 3·1 per cent. of CO_2, 5·9 per cent. of nitrogen, and 0·2 per cent. of oxygen.

Dr. Harold Hartley said in the process of carbonisation they should consider the changes that were taking place in the hydro-carbon contents of the gas. They started with about 30 per cent. of methane and unsaturated hydro-carbons, and in the fifth test they got down to about 15 per cent., while in the complete gasification tests they obtained what was really a slightly enriched water gas. Whilst great attention must be paid to inerts he thought greater attention should be paid to the chemical composition of the gas itself.

Mr. F. Goulden referred to the fact that the report seemed to indicate a limit to economic steaming—that when they reached about 17,000 cub. ft. to 18,000 cub. ft. per ton, which was equal to about 36 per cent., the economic limit had been reached; after that they went back. The amount of fuel that had to be used began to increase, because, after the critical point, it was necessary to introduce heat from the interior of the retort, and the moment that was done it was necessary to recollect that they had to deal with a very bad heat conductor—fireclay, and therefore they must begin to lose.

Professor Arthur Smithells, C.M.G., chairman of the Research Sub-Committee, expressed the thanks of the committee for the manner in which the reports had been received. As to their work he thought the Bill now before Parliament showed a reflection of what they had done. He urged the necessity of continuing the investigations. A good deal was said at the present time about overlapping—a bogey had been made of it; but he did not think there was any danger, provided the agencies were all well constituted, and doing their work in the right way. While the members felt that they must look to the Fuel Research Board to contribute a great deal of information of the utmost importance, they would still believe there was a large field open to the Institution, working through its Research Committees, to carry on work of the kind which it had been doing for the last few years.

This concluded Wednesday's proceedings.

(To be continued.)

FIRST FRENCH HOUSING CONGRESS.—A book entitled "*Premier Congrès de l'Habitation*" gives the proceedings of the first French Housing Congress, which was held in Lyons from October 9 to 12, last year. It is issued by the Imprimerie Noirelerc et Fénétrier, 3, Rue Stella, Lyons, and contains the papers read at the Congress, together with the discussions thereon, concerning the housing problem in France—which is quite as acute with our neighbours as with ourselves—the difficulties in regard to transport and lack of materials with which it is surrounded, and states the means contemplated to overcome these difficulties.

INDUSTRIAL NOTES.

THE average sums earned per shift by men employed in the mining industry in Germany during the last quarter of 1919 and the percentage increase in earnings during the war, *i.e.*, as compared with those of the second quarter of 1914, are given in *The Labour Gazette* for May, which quotes from a German journal. From this we take the following figures: Hewers and trimmers, coal mines, lowest figure 23*s.* (1 mark taken as 11*s.* 8*d.*), or an increase of 380·7 per cent. over the wage of the second quarter of 1914; highest figure 29*s.* 9*d.*, or an increase of 392·3 per cent.; lignite, highest 18*s.* 8*d.*, or 354·9 per cent.; lowest 22*s.* 4*d.*, or 389 per cent.; copper, 17*s.* 11*d.*, or 374·9 per cent. Other metalliferous ores, 16*s.* 4*d.*, or 350·1 per cent., and 22*s.* 3*d.*, or 349·3 per cent. The table gives also figures which are comparable to the above, for other underground workers and surface workers.

The Industrial League and Council announces that its annual convention of employers and employed is to be held in the Town Hall, Manchester, on Tuesday and Wednesday, the 15th and 16th inst. It adds that the Manchester Engineering Council is cordially co-operating in making the necessary arrangements.

The Industrial League and Council was formed five years ago as a result of a few informal conferences which were held between well-known Labour representatives and large employers of labour, to discuss problems which were bound to ensue as a result of conditions brought about by the war. The importance of promoting some definite organisation to help foster public opinion on industrial difficulties and find solutions which would be acceptable to all concerned was immediately realised, and from this unpretentious beginning it has developed into the powerful organisation which it is to-day. Its presidents are the Right Hon. G. H. Roberts, M.P., late Minister of Food, and the Right Hon. J. H. Whitley, M.P., Deputy-Speaker of the House of Commons. It strongly supports the principles of the Whitley Councils and firmly believes that if this country is to regain its old commercial prestige, it can more effectively do so through the medium of conferences of employers and employed, and mutual peaceful understandings, than by any system of party strife or direct action.

When a private industry is taken over by a public authority, says *l'Exportateur Français*, the first manifestation is that the employees decline to recognise any other chief apart from Parliament, which is an assembly they have elected. They place themselves thus outside the laws of general economics and imperiously claim the highest wage without at all taking into account the state of the market. Nationalism invariably leads to promotion by seniority, to the paralysis of all effort, to stagnation and ruin. When a public official is taken from State employment and is placed at the head of a private industrial or commercial enterprise, he becomes frequently an excellent chief, since he feels he is working for his own benefit, instead of working at a rated salary. The conception of duty towards the collectivity acts as a stimulant for characters of the *élite* class, but it does not suffice in the case of ordinary mortals.

Writing in a recent issue of *The Sunday Times*, Lord Leverhulme states that the excess profits duty, the long-discussed war wealth levy, and the corporation tax denudes those who are carrying on our industries of capital for extension and vigorous development. It is not too extreme a parallel to say that it is as if the War Office had decided at some critical period of the war to reduce the number of rounds of ammunition for gun and rifle held by the men in the firing line. Very few businesses in the United Kingdom have not had to go to their bankers to provide the funds required for the excess profits tax. Equally few, if the proposed war wealth levy is carried into effect, will be able to avoid going to their bankers to provide the money to meet that levy. What will be a greater disaster still, many will attempt to realise some of their properties to meet it. It is quite obvious that the effect of this would be a serious and immediate reduction of the credit available for the carrying on of the business industries, shipping and commerce of the United Kingdom. The war loan has the security of the British Empire behind it, not only in material wealth, but in our character, which stands higher than our wealth, great as that may be. The individual industrial company or private citizen called upon for these excessive levies, can only be viewed by their bankers immediately after their payments as being less strong financially than previously, and consequently that their credit must be restricted. We have not only to maintain our national credit, but also to restore British industries. The figures given in the last two Budgets have shown that both these objects can be achieved without excessively denuding our industries or our

citizens of the capital necessary to carry on our industries. It is only a question of the speed at which we shall pay off our national debt. Spread over fifty or sixty years, the charge for interest and sinking fund is not a crushing burden; but an attempt to repay our War Debt in twenty or thirty years is an assassin's blow to our industries, and can only result in unemployment, with its consequent fall in wages and recurrent strikes bordering upon internal revolution. Further on in the same article, Lord Leverhulme says it is work and production we want to win the peace and to deflate prices, and this can only be achieved by ample capital and unrestricted credits. It is full employment we want for our people, and not works shut down or working half-time.

The result of the ballot of gasworkers (referred to on page 611 *ante*), on the question of a strike to enforce the demand for 10*s.* a week increase in wages, a 44-hour working week, and double pay for Sundays and holidays, together with a fortnight's annual holiday with pay, was announced at a meeting of the unions held in London last week. Over 100,000 gas workers throughout the country are affected by the dispute. The meeting decided by vote not to publish the detailed figures of the ballot at present, and issued the following official statement:—

"Ninety-six per cent. of the men employed in the gas undertakings at the present time voted in favour of a strike. Four per cent. were against such action, and the neutrals formed an infinitesimal number. As the gas-working industry is at a low ebb at present many of the men have become scattered, otherwise the vote would probably have been still more pronouncedly in favour of drastic action. Notices to leave work are being prepared, to be tendered to all undertakings, to expire simultaneously on the night of June 26. A negotiating committee has been appointed to wait upon the Ministry of Labour, consisting of Messrs. H. Pickard (London), Alderman H. Simpson (Birmingham), R. Taylor (Newcastle), E. Bowen (Southampton), W. Whiting (Romford), together with Mr. A. Hayday, M.P. (secretary of the National Joint Industrial Council for the Gas Industry) and Mr. James O'Grady, M.P. (general secretary of the National Federation of General Workers). Mass meetings will be held all over the country in order to acquaint the men with the position."

The National Railway Wages Board issued last Friday their award in the matter of the claims made by the two railway unions for increased wages and other conditions. The Board found that the current or "A" rates to the men concerned, other than those in the locomotive and signalmen's grades, shall be advanced proportionately to their pre-war rates by sums varying from 4*s.* to 7*s.* 6*d.* per week in the case of men in districts other than those classified as rural districts, and from 2*s.* to 3*s.* 6*d.* per week in the case of men in rural districts. These sums to become due as from the 14th inst. and to be in addition to the 2*s.* per week due under the operation of the sliding scale as from April 12, 1920.

In the case of the locomotive grades, they are agreed that, to the 3*s.* per week already granted to these men to meet the increase in the cost of living, shall be added the following sums, viz., drivers 7*s.* per week, firemen 4*s.* per week, and cleaners 2*s.* per week (18 years of age and over). These sums also due as from the 14th inst., and to be in addition also to the 2*s.* above referred to. The rates of pay granted to the drivers, firemen and cleaners under the agreement of August, 1919, shall be deemed to be standard or "B" rates. To these shall be added the advances already given since August, 1919, including those now recommended, and the combined figures shall form the current or "A" rates. The difference between the "A" and "B" rates shall be subject to the sliding scale as laid down in the agreement of March 20, 1920, for all other grades in the conciliation scheme.

In the case of signalmen they recommend that, pending the completion of the classification of boxes, which is now in progress, a new system of "A" rates to follow the general principles laid down in the memorandum of agreement of March, 1920, shall be established, and it is suggested that these be arrived at by taking the pre-war maximum of the boxes, adding thereto the existing war wage of 39*s.*, plus the 2*s.* accruing under the sliding scale to cover the increase in the cost of living from 132 per cent. to 141 per cent. above pre war, and a further addition of from 4*s.* to 8*s.* 6*d.* per week (according to the pre-war rates of the box) to the men in industrial areas, and from 2*s.* to 3*s.* per week (according to the pre-war rates of the box) to men in rural districts. These rates to be payable as from the 14th inst.

In regard to the 2*s.* per week due under the sliding scale (advance of cost of living from 132 per cent. to 141 per cent.), they recommend that to avoid clerical labour in compiling the actual amount of arrears due for overtime, night duty, &c., the payment from April 12 to the 13th inst. be at a flat rate of 2*s.* 3*d.* per week.

Drivers and guards to advance to the maximum rate in the sixth instead of in the eighth year.

They considered that the claim of the locomotive engineers and firemen in respect of holidays, rates for overtime, Sunday and night duty, and the exclusion of Sunday from the guaranteed week had not been established.

In publishing their conclusions the Board express the view that the settlement should not be disturbed for such period as will facilitate a return to the stability of industry and commerce, which is so necessary to the well-being of the community. This expression of view is without prejudice to alterations of rates consequential upon changes in the cost of living. They feel justified in recording their view that the absence of any effective system of co-ordinating changes in rates of wages is largely responsible for the fact that wages settlements tend to be disturbed, not because of inherent defects, but because of changes in the comparative level of wages in different trades brought about without due regard to the position outside the industry immediately affected.

They desire with all emphasis to suggest that every effort should be made to ensure that the movements of wages in the different industries should come effectively under review by a co-ordinating authority, and that, in such other directions as may be open, steps should be taken to reduce the cost of living, or at least to prevent any further increase.

The signatories are Sir William W. Mackenzie, chairman; Mr. W. J. Abraham, Mr. W. J. Davis, Mr. E. Manville, M.P., Mr. Henry J. May, Sir T. Robinson, M.P., Sir H. H. Thornton, Sir H. A. Walker, and Sir I. T. Williams.

A separate report was put in by Mr. Donald A. Matheson, which stated that while the affairs of the country were in a transitory state there should be no alteration of any of the rates of wages fixed under the recent agreements, excepting temporarily in respect of signalmen, engine-drivers, goods guards and passenger guards, who, on the precedent set by the high percentages of increase on the pre-war average wages already being paid to the other grades, were entitled in fairness to be fully compensated in respect of the increased cost of living by being paid an average wage of at least 141 per cent. more than the pre-war average wage. That the principle of the flat figure of increase under the sliding scale being unsatisfactory, the sliding scale should be modified to the extent necessary to ensure proper constant relationship to the amount of the pre-war average wage of the several grades. That there should be no recognition of the doctrine of equality of wages in the several industries, regardless of economics and the circumstances attaching to the several industries. That there should be realisation (*a*) of the fact that the burdens which had recently been put on railways had already produced a breaking strain, and (*b*) of the fallacy connected with the charging of higher rates and fares for conveyance than the traffics could bear. That the problem attaching to the economic difficulties of the time should be solved by governing the "shopkeeper" rather than by continually increasing wages.

The action of the Union of Enginemen and Firemen in the Sheffield strike was repudiated by the other unions concerned, who last week issued the following manifesto: "We unhesitatingly declare that the present strike, having regard to the offer made by the Employers' Association, is not only unjustifiable but iniquitous, as it calls upon many thousands of workmen to sacrifice their wages, not to speak of the closing down of our industries, and this in order to gratify the wishes of a small minority of workmen." A meeting of the Sheffield ex-service men's Joint Council, representing the National Federation of the Comrades of the Great War, and other organisations, was held at the same time, when the following resolution was passed: "That we view the present deplorable strike with grave dissatisfaction, realising the hardship created on thousands of men and women (including a large number of ex-service men) by loss of wages, joined with the present high cost of living. We urge the leaders on both sides to make every possible effort to end this crisis, failing which, we propose to call a mass meeting of ex-Service men and women—as we are determined to stop this disastrous state of affairs from continuing." The Sheffield electricians threatened to strike "in sympathy" with the Enginemen and Firemen, but their threat came to nothing. In this connection, it may be added that the Sheffield Branch of the Middle Class Union offered to find 100 practical engineers to maintain the public services in the event of a strike on the part of the electricians. The Rotherham electricians, however, came out on strike later, and the cessation of the current supply caused great inconvenience in the district. At the time of going to press we hear that an agreement has been arrived at.

Speaking last Tuesday at the annual meeting of the National Association for the Employment of ex-Service Men, Lord Haig said that many employers had been prevented by trade unions from giving employment to these men for whom they were willing to find jobs. Despite all the efforts made by the Association and others, by Government Departments and private individuals, there were only too many cases of deserving ex-Service men who were still fighting perhaps the hardest battle of their lives in endeavouring to find work which would keep themselves, their wives and their families from absolute starvation. Ex-soldiers ought not to be left to fight their battles unaided; they wanted and desired active help from every section of the community, and not less from those in their own walk in life. The inability of the ex-soldier to earn a full trade union wage was due to the fact that some of his best years were given up at the risk of his life in fighting for his country, and thereby in fighting, among other things, for the very existence of the trade unions. He (Lord Haig) did not ask the trade unions to abandon their principles, but he did ask them and the employers to endeavour, even at some sacrifice, to meet exceptional circumstances by some exceptional action. It was their turn for action, the ex-Service men had already given theirs.

"German and English Commercial Correspondence."—This is the title of a booklet of the well-known Marlborough self-taught series issued at the price of 1*s.* 9*d.* net by Messrs. E. Marlborough and Co., 51, Old Bailey, E.C. 4. Its object is to help British students of the German language to acquire proficiency in commercial correspondence in the latter language, and it contains a very large number of examples of business letters and phrases. We greatly welcome the publication, and hope it will have a wide circulation. By mastering its contents—and this is in no way difficult to anyone interested in the language—British commercial and other clerks, besides improving their situation, will be doing a work of great national importance in that they will be contributing to keep out from this country a vast number of undesirable aliens.

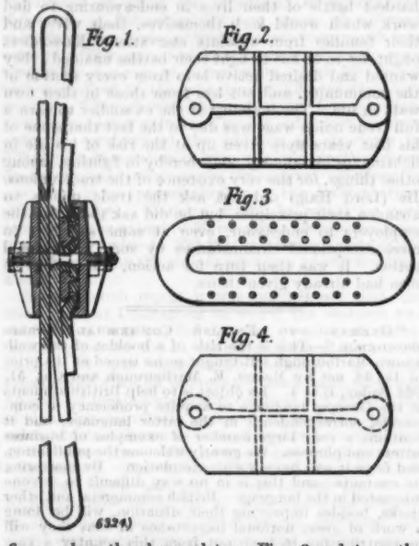
Export of Galvanised Sheets.—An interesting feature of American steel export trade since the war has been the movement in galvanised sheets, says *The Iron Age*, New York. A constant expansion has been in progress until, for 1919, these exports exceeded the figures for 1913 by over 33 per cent., or 101,600 gross tons, as against 71,200 tons. The 1919 rate of 8,500 tons per month is still being maintained. The heaviest buyers are the South American countries, Canada, Australia and Japan in the order mentioned. In 1919, South America took about 17 per cent. of the total exports, Canada about the same and Japan about 15·5 per cent. British exports of galvanised sheets, only 736 tons per month in 1918, increased, in 1919, to 15,500 tons per month, and in the first quarter of this year were 53,280 tons per month. Before the war, Great Britain was the largest exporter of sheets, the figures for 1913 having been 63,500 tons per month. The world's demand for galvanised sheets is very heavy. In 1913, 839,255 tons, or 70,000 tons per month, represented the combined British and American exports. These exports amounted to only 69,500 tons in 1918. Last year they were 287,700 tons, or still only about one-third of the pre-war exports. When one considers the reduced operations of Continental Europe in the manufacture of sheets, the facts spell unmistakably a world demand for American and British galvanised sheets of large proportions for some years to come and a certain activity in the foreign American zinc trade as well.

German Chemical Reichsanstalt.—The new Chemikalisch Technische Reichsanstalt, the organisation of which is now being discussed by the German Diet, is to be an institution analogous to the well-known Physikalisch-Technische Reichsanstalt, and is to work on lines somewhat similar to those of our Department of Chemical Technology at South Kensington. No special provision is to be made for Fuel Technology, however, which is one of the main sections at South Kensington,* since coal research has already its own home at Mülheim. Among the main objects of the German institute are investigations of raw materials and of substitutes for rare materials, the utilisation of by-products, and the standardisation of tests; further, the prevention of accidents and the protection of the workers in connection with factory inspection, safety in mines, testing of masks and other apparatus, research on spontaneous ignition, &c. General factory economics and organisation, which are among the aims of the studies at South Kensington, do not appear to be included in the programme. The general scheme follows indeed more closely that of the Physical Reichsanstalt, with which it is not to interfere, and which is not an educational institution. Rust prevention and the influences of cold and high altitude on certain materials are among the problems for immediate research. The staff of the Military Experimental Station, which has collected a good deal of information during the thirty years of its existence, will form a nucleus of the new staff.

* See Engineering, November 1, 1918, page 500.

DROP-HAMMER BELT FASTENER.

THE strain on drop-hammer belt joints is very severe, and often causes trouble when the ordinary type of fastener is adopted. Messrs. Lewis and Tylor, Limited, 51, Gracechurch-street, E.C., have given this point some attention and have evolved a simple grip for such belts which overcomes all tendency to slip. This is known as the "Gripoly" belt clamp. This fastener is illustrated in Figs. 1 to 4 herewith, which will be readily followed with a brief explanation. Fig. 1 shows a section of the joint made, while the remaining

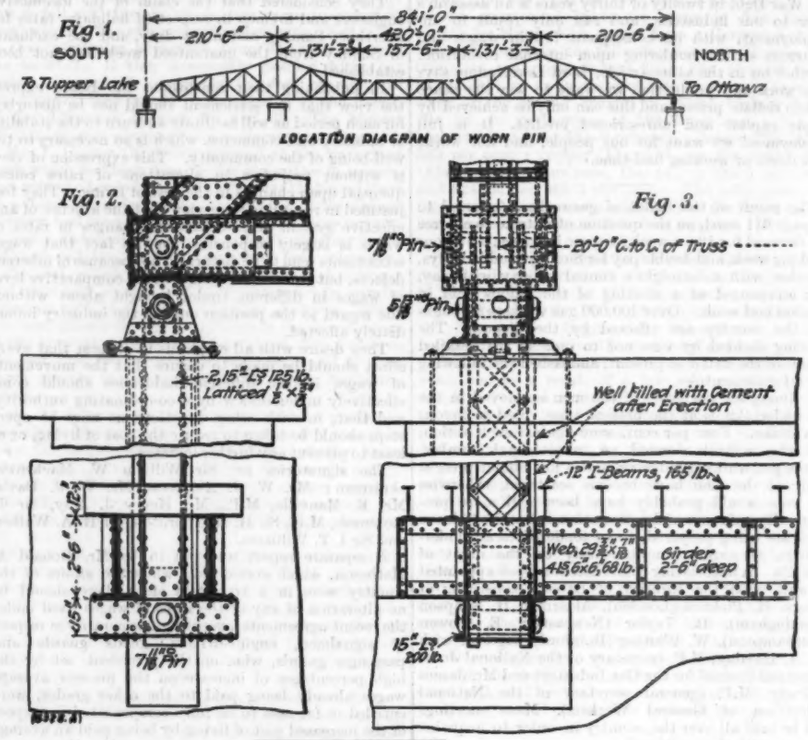


figures show the clamp plates. Figs. 2 and 4 are the outside plates, Fig. 3 being the centre or bridle plate. The belt ends are passed through the latter and turned back, the clamp plates being screwed down over the turned down ends. The centre plate is provided with teeth which, on screwing up, are forced into the belt fibre. The top outside clamp has lipped edges, and fits over the belt ends and centre plate, and when the clamps are screwed together it will be seen that a very effective grip is produced on the belt, even with a comparatively moderate pressure on the screws. The belt is not pierced by any large holes nor weakened in any way, as the clamping bolts are outside the width of the belt. It is moreover a joint which can very quickly be remade, should adjustment be necessary.

YEAR BOOK OF SCIENTIFIC AND LEARNED SOCIETIES.—The thirty-sixth annual issue of the Year Book of the Scientific and Learned Societies of Great Britain and Ireland, contains a record of the work done by these bodies during the session 1918–19. It gives also the address, offices, dates of meetings and membership fees of each society. It is published at the price of 9*s.* net, by Messrs. Charles Griffin and Co., Limited, Exeter-street, Strand, W.C. 2.

MINERAL PRODUCTION OF THE BRITISH EMPIRE.—The survey of the progress, made during the last twenty-five years in the mineral production of the Empire, which Mr. Frank Merricks gave last month in his presidential address to the Institution of Mining and Metallurgy, was on the whole very satisfactory. In most cases the supply of raw materials is amply assured, many sources are controlled, and the list of ores and metals which can only be obtained from foreign countries, is not long. On the other hand, the general output of minerals has decreased of late owing to international warfare and labour troubles, and the conservation of mineral resources is claiming very serious attention. As regards gold the British Empire produced, in 1914, 64 per cent. of the total output (76 per cent. of this coming from Africa). The silver production of Canada, now 63 per cent. of that of the Empire, had risen from 66,776*l.* in 1893 to 3,770,000*l.* in 1917. The copper production is still small, the 1,415,000 tons of 1917 representing only 7 per cent. of the world's output, while 25 per cent. of the lead comes from the Empire. In zinc the United States and Australia keep the lead; Broken Hill produced 260,000 tons of spelter in 1917 and 300,000 tons in 1918. The chief source of tin, the Malay States, being British, half of the world's tin comes from the Empire, and British smelting and refining works deal also with foreign tin ores and metal. The nickel output of Sudbury, Canada, estimated at 451,000*l.* in 1893, had risen to 7,000,000*l.* by 1917, and Canada will soon be the largest refiner of the metal. Almost all the asbestos of the world's output (164,000 tons in 1918) is now mined in Canada and the Empire; as to mica, India ranks first. The main sources of bauxite are France and the United States, but India and British Guiana are becoming important, and six bauxite areas of the latter country have been leased to the Northern Aluminium Company, of Quebec.

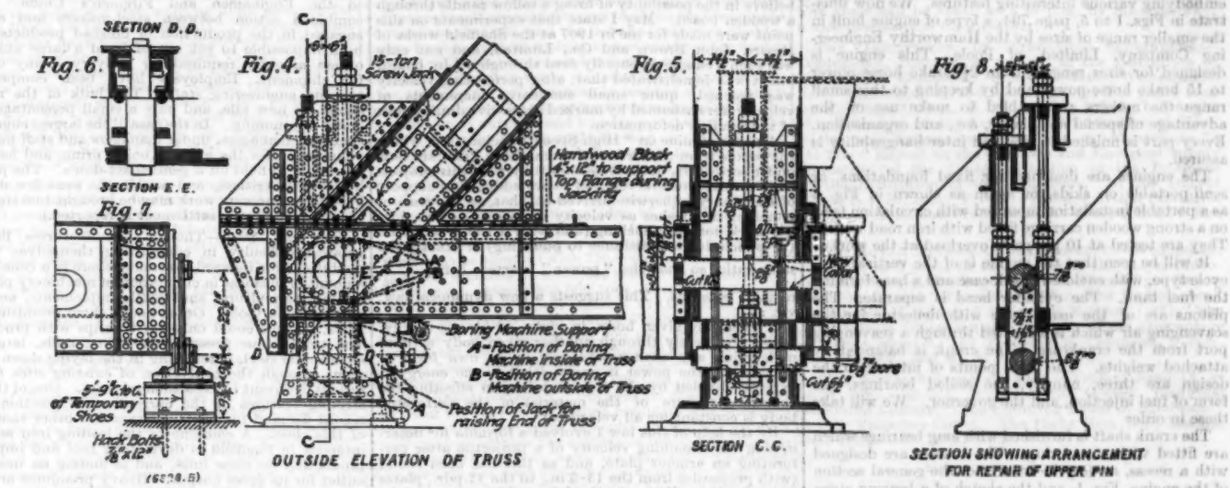
RENEWING ANCHOR-PINS; CORNWALL CANTILEVER BRIDGE OVER THE ST. LAWRENCE.



WE reproduce on this and the opposite page engravings which have been published by *Engineering News-Record* to illustrate the feat of replacing the worn anchor pins of the Cornwall cantilever bridge, by which the trains of the New York Central Railroad cross the St. Lawrence. We give below an abstract of the description which accompanied the illustrations. This was written by Mr. H. T. Welty, engineer of structures for the New York Central Railway Company.

The bridge was built in 1898, and its general character is shown in Fig. 1. The total length is 841 ft. between the anchor pins, and the central span measures 420 ft. between centres of piers. The bridge carries a single track and was designed for Cooper's E 35 loading, but has now to carry loads equivalent to Cooper's E 42 loading. The anchor pins which were originally provided wore owing to the constant reversals of stress to which they were subjected, and this wear and the increase in the loads taken both led to high stresses in the pins. As shown in Figs. 2 and 3, the shoe on which the end of the truss rests is connected by two channels to a bearing against two transverse girders embedded in the masonry of the pier. Links permitting of longitudinal motion connect the end pins of the trusses to pins through the shoes and anchorage channels. The work involved four main problems: (1) Design of an auxiliary supporting system strong and rigid enough to retain the bridge members in position under traffic so as to permit a boring tool to cut through these members with absolute accuracy; (2) provision in this supporting system of means for adjusting the bridge members meeting at the pin so as to free the pin from load; (3) the designing of the supporting system so that while no movement of one bridge member to another could take place the anchor span as a whole could move freely in a horizontal direction; (4) the design of a machine which would bore out the old pins and would at the same time produce holes for the new pins through all the members in perfect alignment. The supporting system adopted is illustrated in Figs. 4 to 8, the opposite page. Brackets for jacks were bolted to the top flanges of the bottom chords and to the webs of the end posts, and with 25-ton jacks the pressure of the end posts was removed from the pin. Brackets connecting the end post and bottom chord were then securely fixed in place as shown in Fig. 4. The end brackets were connected to a short cross-girder secured to the end of the bottom chord. Castings bolted to this cross-girder engaged link bars capable of taking the upward or downward reaction. These bars were coupled to a bearing on a steel grillage anchored to the pier. The pin holes were slightly ovalised so that no negative reaction could be taken by these links, provision for this being made by other means. The bottom chord was next jacked up sufficiently to relieve the upper pin of all positive load, and shims and wedges were driven under the supports of the cross-girder, thus relieving the lower pin from any positive load. No traffic was allowed over the bridge whilst jacking was in progress, but as soon as the temporary parts were secured, train operation was resumed. Threaded rods bearing at the top on channel beams and at the bottom on angles riveted to the truss shoe, were provided to take the negative reaction or uplift. Similar rods were also used to champ saddle castings to the old pins to hold them accurately in position during the boring operations. After the load had been thus removed from the pins, traffic was maintained for a day or two in order that any slight yielding of the temporary parts might be corrected before proceeding to the boring operation. The maximum positive reaction to be taken was 512,000 lb., and the negative reaction 270,000 lb. The boring machine used is illustrated in Figs. 9 to 12. It was made in the railway company's shops, and comprised a spindle threaded at the end to screw on to the pin around which a new hole was to be bored. This is clearly shown in Fig. 9. In this way the tool was accurately centred with the axis of the old pin. The cutting tool was of the trepanning type, and was provided both with hand and automatic feeds. It was driven by an air motor, an electric drive first tried proving unsatisfactory. The lower pin, that in the shoe, was bored first. It was freed from load and securely clamped; and boring was started after the last train had passed at night. The old pin was $5\frac{1}{16}$ in. in diameter, and the new hole was $6\frac{7}{8}$ in. diameter and the distance to be bored at each end to get through both shoe and link was $6\frac{1}{2}$ in. The time taken averaged about 3 hours, and 2 hours were required to shift the machine from one end of the pin to the other end of it, to complete the operation. After both ends had been bored, the pin was removed and the hole calipered. The pin was then replaced and wedged against the new hole, whilst the new pin was sent to a local machine shop to be reduced to the exact dimensions required. This operation took 5 hours, and the new pin was then inserted in place of the old. The same procedure in essentials was followed in boring the new hole round the

RENEWING ANCHOR-PINS; CORNWALL CANTILEVER BRIDGE OVER THE ST. LAWRENCE.


SECTION D.D.
Fig. 6.
Fig. 4.
15-ton Screw Jack
Hardwood Block 4"x12" to support Top Flange during Jacking
SECTION E.E.
Fig. 7.
Boring Machine Support
A=Position of Boring Machine inside of Truss
B=Position of Boring Machine outside of Truss
Position of Jack for raising End of Truss
5'-9" C. to C. of Temporary Shoes
Hook Bolts 7/8" x 12"
OUTSIDE ELEVATION OF TRUSS
Fig. 5.
SECTION C.C.
Fig. 8.
SECTION SHOWING ARRANGEMENT FOR REPAIR OF UPPER PIN

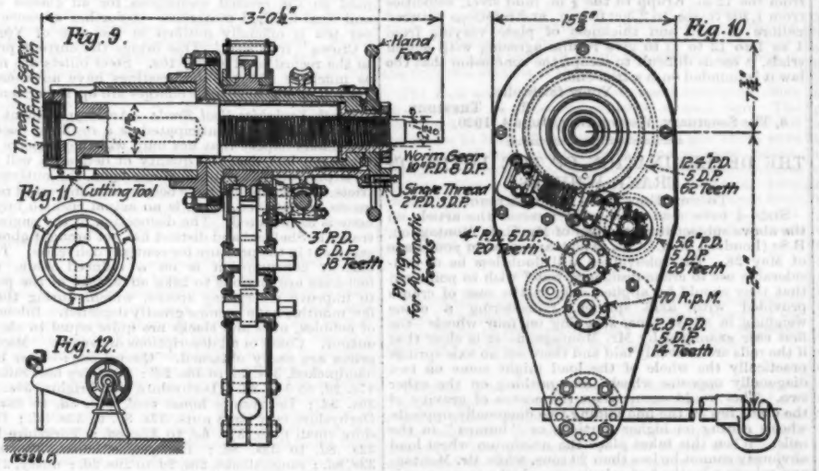


Fig. 9.
Hand Feed
Worm Gear 10" P.D. 6 D.P.
Single Thread 2" P.D. 3 D.P.
Plunger for Automatic Feeds
Fig. 11. Cutting Tool
3" P.D. 6 D.P. 18 Teeth
Fig. 12.
Fig. 10.
12.4" P.D. 5 D.P. 62 Teeth
4" P.D. 5 D.P. 20 Teeth
5.6" P.D. 5 D.P. 28 Teeth
70 R.P.M.
2.8" P.D. 5 D.P. 14 Teeth

7⅛ in. pin in the end of the truss. Here, however, the operation was more difficult as the pin passed through six separate members, making it necessary to bore to a distance of 10 in. from each end. The work was, therefore, done on Saturday nights, so as to occasion the least possible interference with the traffic—few trains being run on Sundays. The holes proved to be extremely accurate and the pins fitted them in all parts to within 0·012 in. With the old worn pins in place there was a vertical movement of $\frac{3}{4}$ in. at each anchorage on the reversal of the reaction. After the work of replacement was completed this movement had been practically eliminated and probably did not exceed $\frac{1}{16}$ in.

THE DEVELOPMENT OF GERMAN WATERWAYS.

ALTHOUGH Germany is doubtless now beset with many economic difficulties, there is no lack of effort on the part of the intelligent section of the nation to improve matters and to prepare the way for what developments the future may have in store. The importance of facilitating transport is fully realised, both in the matter of increased capacity and of lower rates, and it seems to be generally agreed that the country's waterways are destined to play a very important part in this connection. It is therefore proposed to increase the capacity of existing waterways and also to extend them so as to facilitate co-operation between the different systems.

The history of German waterways shows a steady, and in many cases, a rapid development. Thus the locks of the Tinon canal were constructed in 1846 for vessels of 170 tons; while in 1874 the Elbe-Spree Canal was constructed for vessels of 300 tons, and in 1877 a capacity for vessels of 350 tons was adopted for the Rhine-Weser-Elbe canal. The Dortmund canal was planned in 1882 for 600 ton vessels, and was actually constructed in the early nineties for vessels of 600 tons; it was, however, afterwards deepened so as to accommodate vessels of 750 tons. At the present time a capacity for vessels of 1,000 tons is considered essential for German canals, and this corresponds with a draught of 2 metres and a depth of water of 2·2 m. In Bavaria the construction of the Danube-Main canal for vessels of 1,200 tons is under consideration. At the same time as the canals are enlarged, the plant for loading and discharging is to be made more efficient, so that the minimum time will be lost at terminals.

The present position of the principal German rivers as regards depth of water is as follows: a draught of 1·8 m., with minimum depth of water of 2 m. is available in the Rhine, with average low water, as far as Philipsburg, 34 km. above Mannheim, and with ordinary water level the same depth is obtained as far as Kihl; in the Weser with ordinary water level the same depth can be obtained as far as the mouth of the Aller; in the Elbe with average low water and duly regarding the tide the depth of 2 m. exists as far as Hoopte, the mouth of the North-South canal, 20 km. above the Hamburg railway bridge, and with ordinary water level, as far as the mouth of the Eger in Bohemia; in the Oder the same depth is available to Hohensaatken, the mouth of the Berlin-Stettin canal, and to Lossow, the mouth of the Frederick-William canal under low water and ordinary water conditions respectively. According to the Act of December 24, 1911, relating to the development of German waterways, the following depths of water in the different German rivers were provided for: in the Rhine, with average low water, 2 m. as far as Strassburg; in the Weser with increased average low water (obtained by the construction of dams) 1·10 m. between Münden and Karlshafen 1·25 m., as far as Karlshafen, 1·50 m. as far as Minden, and 1·75 as far as the mouth of the Aller; and in the Elbe 1·10 m. above and 1·25 m. below the mouth of the Saale. According to expert opinion these are the greatest depths which can be attained without regular canalisation, but in a dry summer such as 1911, this depth of water cannot be maintained and shipping has frequently had to be suspended in places.

The present programme for further development of the waterways of the German Empire comprises a central German system of waterways in connection with the North-South Canal and a system of canals between the Weser and the Elbe, in connection with the Danube and the Oder, and the Main and the Rhine. The plan is based upon the principle that these waterways would be suitable for the navigation of 1,000-ton vessels in the dry season. By carrying the Mittelland Canal from Hannover to the Elbe at Magdeburg a connection will be established with Hamburg and with the Baltic through the Elbe-Trave canal via Lübeck. By this means a complete substitute for the Elbe at low water in dry periods will be obtained, and, moreover, the distance between Hamburg and Magdeburg by the Mittelland Canal is 33 kiloms. shorter than by the Elbe route; also if the Mittelland Canal is carried over the Elbe by a bridge as far as the Ihle Canal it will establish a connection for full-sized vessels between the whole of the Mark Canal system and Hamburg.

The Austrian canal system will also be benefitted by the new German canal schemes and by the connection thus established with the leading German ports. The distance by water from Vienna, *viâ* Breslau, to Stettin is about 1,000 kiloms., while to Hamburg by way of Dresden, the central German canal system, and the North-South Canal, it is 1,165 kiloms., and by way of Steppberg, Bamberg, Gemünden, Lehrte, and Hooyte, 1,387 kiloms; the distance through the Danube-Main Canal, down the Rhine to Rotterdam, is 1,596 kiloms., and the distance from Vienna, down the Danube, to the Black Sea, is 1,910 kiloms.

It may be of interest to note that the sea-borne traffic of the German ports amounted to 51,042,000 tons during 1913, in which year the river traffic of the same ports totalled 25,607,000 tons. The importance of an extended and improved system of internal waterways is further proved by the fact that although Germany possessed very rich and valuable coal deposits, she imported coal to the value of 289,000,000 marks during 1913, principally from England. This was mainly due to the absence of an efficient waterway system connecting the coal deposits with the large centres of consumption. During 1913 198,000,000 tons of coal, or 86 per cent. of Germany's entire production, was transported by rail and only 14 per cent. by water.

STEEL-MAKING IN FRANCE.—With plenty of iron, but an insufficient amount of coal, says *The Iron Age*, New York, the French iron and steel industry is in much the same position as before the war. A detailed analysis of the situation has just been forwarded by Consul Ernest L. Ives, from Paris. Mr. Ives tells at length of the conditions in the industry in France and of the various developments during, and growing out of the war. Alsace-Lorraine produced in the first six months of 1919, 44·6 per cent. of the iron, 32·1 per cent. of the steel, and 28·4 per cent. of the finished products, manufactured in all France.

TELEPHONE CABLE, GERMANY-SWEDEN.—The submarine telephone cable Stralsund-Malmö, which was completed last December, has a length of 139 km., and is thus by nearly 40 km. longer than the telephone cable between England and Belgium dating from 1916. The new cable is not of the Pupin type, but of the Krarup type; it was made by Felten and Guilleaume, of Mülheim, and the Norddeutsche Seekabelwerke. There are four conductors, each of seven copper wires of 0·8 mm. diameter; each of the stranded conductors is wound with one layer of annealed iron wire, 0·3 mm. in diameter, and then wrapped with paper to bring the diameter up to 5·8 mm. Further paper insulation of the four conductors increases the core diameter to 15·5 mm.; outside this are two lead sheaths, each of 1·6 mm., two layers of tarred paper, jute, and an armour of 22 wires of tarred galvanised iron. The complete cable, 40 mm. in diameter, weighs 7 kg. per metre and was supplied in sections of 70 km. maximum. Siemens cathode tubes (i.e., thermotonic valves), worked at 220 volts, intensify the sounds. The four conductors form two closed circuits.

THE HAMWORTHY TWO-CYCLE ENGINE.

THE popularity of the two-cycle oil engine has led to an almost endless variety of this form of motor, and we are constantly noticing in these columns designs embodying various interesting features. We now illustrate in Figs. 1 to 5, page 794, a type of engine built in the smaller range of sizes by the Hamworthy Engineering Company, Limited, of Poole. This engine is designed for sizes ranging from 2½ brake horse-power to 15 brake horse-power and by keeping to this small range the makers are enabled to make use of the advantage of special machinery, &c., and organisation. Every part is finished to jigs, and interchangeability is assured.

The engines are designed for fixed foundations, or semi-portable on skids, or again as shown in Fig. 4 as a portable installation mounted with circulation tank on a strong wooden carriage fitted with iron road wheels. They are tested at 10 per cent. overload at the works.

It will be seen that the engine is of the vertical two-cycle type, with enclosed crank case and a base forming the fuel tank. The cylinder head is separate. The pistons are of the usual type with deflector for the scavenging air which is admitted through a scavenging port from the crankcase. The crank is balanced by attached weights. The main points of interest in the design are three, namely, the sealed bearings, the form of fuel injection, and the governor. We will take these in order.

The crank shaft is furnished with long bearings which are fitted with a seal ring. The brasses are designed with a recess, as may be seen from the general section of the engine, Fig. 1, and the sketch of a bearing given in Fig. 5. It will be seen that no wear occurs on this ring which floats on the shaft, and as it is not constrained by the shaft to take up any particular position longitudinally it can adjust itself in this direction to the bearing. This results in a minimum amount of wear on the sides of the ring and the slot of the bearing brasses. Fig. 5 illustrates in somewhat exaggerated form what happens when the bearings are badly worn. The shaft rests on the bottom brass, but the sealing effectively closes against the outer side of the slot in the brass and prevents leakage.

The fuel is injected into the cylinder after the exhaust ports are closed. The consumption of these engines is said to work out at about 0·5 point per brake horse-power hour for the 9 brake horse-power engine at full load, and for the smaller 5 h.p. size about 0·6 pint. In addition to working on refined oils, the two larger sizes can be used on light residual oils of specific gravity up to about 0·89, using a starting lamp instead of magneto. A blow lamp is used to heat the cylinder cover in this case.

The engine illustrated is fitted with electric ignition. The fuel is injected against a deflector plate which forms the cylinder cover. This is seen in section in Fig. 1 while a cross-section of it is shown in Fig. 3. The deflector is ridged so that the fuel is deflected downwards and also out towards the sides whereby very satisfactory distribution is said to be obtained. The deflector is held in place by a clamp ring, and it will be seen to require a minimum of machining so that it is not an expensive feature to replace should such a step be necessary, as sometimes happens with all engines in which the cylinder head has to be heated.

The governor is of the shaft type and is shown in section in Fig. 1. In it there are two spring controlled weights which by their movement adjust the throw of the eccentric working the fuel pump. The eccentric sheave is fitted with a large slot in which is a sliding block fixed to the crank shaft. The weights cause the sheave to move on this block, away from or towards the shaft centre, thus increasing or diminishing the throw. A maximum throw is provided at starting, and as the governor weights move out radially under the influence of the increasing speed the sheave is shifted so that the throw is diminished until normal running is attained. The maximum variation from full load to no load and *vice versa*, is said to be within 5 per cent.

The engines are very simple and will stand a lot of rough usage; and they are suitable for all kinds of small jobs. A large number are now being turned out for irrigation purposes.

"COLLISION DYNAMICS": ERRATA.—Sir George Greenhill has called our attention to one or two misprints which have occurred in the series of articles on "Collision Dynamics" recently completed in these columns. In our issue of April 30 last in the third column of page 565 the formula $v_2 - v_1 = e(v_1 - u_2)$ occurs on line 28 after the words "On Newton's law of rebound." This formula should read $v_2 - v_1 = e(v_1 - v_2)$. Again, on page 670 of our issue of May 21, in lines 7 and 8, from the foot of the first column L has been printed in two cases for l. The phrase commencing on line 9 from the foot of the column should read: "so that with l in metres $l R^2 = 900 \times 0{\cdot}994 = 894{\cdot}6$, but with l in inches, $l R^2 = 39{\cdot}1393 \times 900 = 35225$," &c. We much regret that these errors escaped our notice.

"COLLISION DYNAMICS."

TO THE EDITOR OF ENGINEERING.

SIR,—From the concluding words of his valuable article on "Collision Dynamics" in your issue of May 28, it is to be gathered that Sir George Greenhill does not believe in the possibility of firing a tallow candle through a wooden board. May I state that experiments on this point were made for me in 1907 at the Sheffield works of Messrs. John Brown and Co., Limited, and not only was such a candle repeatedly fired through a ½-in. board, but it was demonstrated that, after perforating velocity was reached, quite small successive increments of velocity were attended by marked successive diminutions of the candle's deformation.

A paper of mine on "High-Speed Punching," of which the proofs from the Ordnance Committee Press are now under correction, deals somewhat fully with this subject. In it the experiments referred to are adduced in support of the theory, otherwise arrived at, that, as the time of punching diminishes as velocity increases, so also does the work done in punching (and with it the pressure on the punch due to resistance to punching) in exactly the same ratio, so that the "power" exerted, being $\frac{\text{work}}{\text{time}}$, remains constant. This suggests a new dynamical law, viz.:—

"When any given body, in virtue of kinetic energy, passes completely through another given body without undergoing any change whatever in its own form or dimensions, the power it exerts (that is the energy it expends divided by the time it takes) in effecting the necessary rupture of the material of the perforated body is constant for all velocities."

By the help of this law I evolved a formula for determining the remaining velocity of a projectile after perforating an armour plate, and as this has been found (with projectiles from the 13·5 in., to the 12-pdr., plates from the 12-in. Krupp to the ¼ in. mild steel, velocities from 1,300 ft.-sec. to 2,300 ft.-sec., and relations between calibre of shell and thickness of plate varying from 1 to 1 to 12 to 1) to give results agreeing with actual trials, it seems difficult to escape the conclusion that the law it is founded on is a true one.

Yours faithfully,

T. J. TRESIDER.

8, The Sanctuary, Westminster, June 4, 1920.

THE DETERMINATION OF THE LOADS ON CRANE WHEELS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest the article on the above subject from the pen of Mr. E. L. Montagnon, B.Sc.(London), A.M.I.C.E., which appeared in your issue of May 28. The rules given will doubtless be of considerable use to crane designers, but I wish to point out that they should be applied only in the case of cranes provided with axle springs. Considering a crane weighing in all 40 tons, standing on four wheels—the first case examined by Mr. Montagnon—it is clear that if the rails are unevenly laid and there are no axle springs practically the whole of the load might come on two diagonally opposite wheels, and nothing on the other two. This would occur when the centre of gravity of the crane lies on the line joining two diagonally opposite wheels resting on higher portions or "bumps" in the rails. When this takes place the maximum wheel load obviously cannot be less than 20 tons, while Mr. Montagnon rejects a method of calculation which gives a maximum load of 16 tons in preference for a method giving only 15 tons maximum wheel load. It is true that Mr. Montagnon postulates a rigid crane structure and a level track, but in practice tracks seldom are perfectly level and the more rigid the crane carriage (*e.g.*, a cast-iron carriage), the greater will be the effect on the wheel loads of a slight irregularity in the track.

In certain cases springiness of the crane carriage will, to some extent, have the same effect as axle springs, and small irregularities of the rails will be taken up. Consider, however, the case of a crane of the portal, semi-portal, or underhung type, having the revolving structure fixed near one end of the bridge and the jib parallel to the track.

The bridge will have to resist a twisting moment due to the load being hung over one side, and since the crane superstructure is not in the centre of the bridge, one end of the bridge will be stiffer to resist this twisting moment than the other. Assuming that the crane stands on four wheels, the wheel base being equal on the two sides of the crane, then the two wheels nearer the revolving structure will be called upon to resist a greater proportion of the twisting moment than the two wheels at the other side of the crane. Mr. Montagnon's method of calculation, however, always makes the difference between the loads on the two wheels on one side of the crane equal to the difference between the loads on the two wheels on the other side; in other words, it divides the twisting moment equally between the two sides, and is therefore unsuitable in such cases.

Finally, in the case of a crane standing on six wheels—three wheels equally spaced each side—with the revolving structure mounted at the centre of the carriage and the jib at right angles to the rails, the maximum wheel load will tend to come on the centre wheel at one side of the crane, any springiness of the carriage side tending to relieve the two outer wheels. But in this case, also, comparatively small irregularities in the rail will considerably affect the distribution of wheel loads, and the only way to make sure of obtaining much reduction of maximum wheel load from the increased number of wheels is by providing axle springs.

Yours faithfully,

W. W. PADFIELD.

2, Cedar Villas, Bath, June 5, 1920.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Steam Service Strike.—Quite 30,000 men engaged in engineering work are idle to-day as a result of the precipitate action of the steam service men belonging to the Enginemen and Firemen's Union. Despite combined action between steel-makers and concerns engaged in the production of finished products, it has been impossible to get out of hand a large number of orders urgently required for delivery, many of them for shipment. Employers have been compelled to suspend engineering staffs. The bulk of the machine shops are now idle, and only a small percentage of the lathes are running. In the case of the largest engineering concerns, managers, under managers and staff men have volunteered for the work of boiler firing, and have thus been able to hold off a general set-down. The position, however, is critical, and within the next few days the bulk of engineering work may be brought to a standstill. (As we go to press a settlement is reported.)

Iron and Steel.—Though manufacturers find the greatest difficulty in committing themselves to firm quotations for forward contracts, there is a considerable amount of business in circulation in machinery products, mining, agricultural and textile implements, and hand and machine tools. Order books show promising prospects, if firms could only get to grips with production. The tremendous pressure on rolling mills, largely for automobile steel, is resulting in the laying down of new plant, though the congestion of existing sites forms a serious deterrent to expansion schemes. One of the most striking features of the current trade position is the record demand for pliers, pincers and other small tools of this class. A combine of the leading iron and steel interests in Sheffield is developing tool and implement production on mass lines, and is finding an immediate outlet for its gross output. Heavy premiums are being paid on the revised quotations for all classes of raw and semi-finished materials. A further advance of 2*l.* per ton is officially notified in the case of Yorkshire "Crown" iron bars. This brings the current price up to the record level of 30*l.* 10*s.* Steel billets are making as much as 36*l.* per ton, castings have advanced 50*s.* per ton, and rolling mills charges are up 15 per cent.

South Yorkshire Coal Trade.—An improvement in the house-coal trade is anticipated as a result of decontrol. Merchants expect that not only will they receive larger tonnages, but that the quality of deliveries will revert to a pre-war character. While from the outlying districts, where supplies have been scarce, increased requirements are notified, there is no actual rush to buy, and none is anticipated. The dislocation of the engineering trades in Sheffield and district has not brought about any easement in the pressure for contract deliveries. Though current consumption is on a reduced scale, manufacturers are anxious to take advantage of the position to improve emergency stocks, which, during the past few months, have become greatly depleted. Inland sales of cobbles, nuts and slacks are quite equal to the gross output. Cokes of all descriptions are scarce. Maximum prices are easily obtained. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little new to report concerning Cleveland pig-iron. Supply is, if anything, more inadequate than ever. No iron is coming on the market for sale to foreign customers, and there are consequently no export quotations. Output indeed is insufficient to fully meet home needs, but there is some little possibility now that the coke supply is better, of production being increased by the blowing-in of one or two idle blast furnaces. Makers are endeavouring to forward to Scotland supplies that were held up during the recent dockers' strike. For home use No. 1 is 230*s.* and No. 3 and the lower qualities of Cleveland pig-iron are 217*s.* 6*d.*

Hematite Iron.—Hematite is little less scarce than Cleveland pig-iron. Makers are not keen sellers, many of them indeed being booked as far ahead as they care to commit themselves, and orders are difficult to place. A little home and foreign business is, however, passing. To home customers, Nos. 1, 2 and 3 East Coast brands are 260*s.* and No. 1 is 262*s.* 6*d.*; and for export to France, Belgium and Italy, mixed Nos. are 265*s.* and No. 1 is 267*s.* 6*d.*

Foreign Ore.—Business in foreign ore is practically at a standstill. Consumers not only have very considerable stocks, but they have large supplies coming forward in fulfilment of contracts, and they are holding off the market altogether for the present. Sellers, however, are taking a firmer stand, and point to rising prices of ore at the mines, and upward turn freights have once more taken. Steamers Bilbao-Middlesbrough have been fixed at 27*s.* 6*d.*, and 28*s.* is now asked. Nominally the c.i.f. Tees value of rubio, of 50 per cent. quality, is 60*s.* to 61*s.*

Coke.—Coke keeps strong with considerable home business doing. Heavy local requirements are understood to be receiving adequate attention. Medium blast-furnace kind is 62*s.* 9*d.* at the ovens, and quality low in phosphorus is 65*s.* 3*d.* at the ovens; whilst

foundry description is 70*s.* 3*d.* for home purposes. For export gas-house product is 165*s.*, and foundry and furnace coke are 150*s.*

Manufactured Iron and Steel.—Finished iron and steel manufacturers have much more work on hand than they can cope with, and they are not seeking further orders, but ominous signs are not wanting that pressure for supply is likely to be less insistent. Producers admit that quotations have touched a dangerously high level. Continental customers are hesitating to pay the rates now named, and some attempts to trade with the Far East have proved unsuccessful. Among the recognised market quotations are: Common iron bars, 30*l.*; marked bars, 32*l.*; rivets, 38*l.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 23*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy sections of steel rails, 23*l.*; and fish plates, 28*l.*

Ironstone Miners' Overtime.—An agreement has been reached with regard to overtime rates of pay in the Cleveland ironstone mines whereby all classes of workers will receive time and a third for overtime during the week, and time and a half for overtime worked during the week-end which extends from noon on Saturday to midnight on Sunday. The effect of this is that an ordinary overtime shift, during the week, for underground workers will consist of 5 hours and 40 minutes, and for surfacemen 5 hours and 20 minutes.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—A large volume of trade continues to be put through in all branches of industry, and on all hands there is as much work booked as to ensure present conditions for a number of months yet. The difficulty experienced in securing deliveries of material adequate to requirements causes delays in production which are keeping back business generally, and so outputs all round are in arrears. The home trade is making heavy demands on local producers with the result that the present foreign trade is of very small proportions. Shipbuilders are all busily employed and with the strike of platers' helpers now settled the yards are again in full swing. Engineering firms—all branches, electrical and mechanical—have much work on hand, and are turning out a great amount of work. Tube makers are likewise very busy, and nail makers, as well as many other manufacturing concerns, have very full order books and steady working is assured for some time. The general textile trade of the district is still good and many orders have recently been placed for new machinery of all classes. Prices of everything keep mounting upwards, and there seems to be little possibility of things easing off in the immediate future.

Scotch Steel Trade.—No change falls to be noted in the state of the Scotch steel trade, and all the works are fully employed. With their deliveries so much in arrears the makers generally are very reluctant to face new business, of which there is quite a lot on offer, and buyers have therefore to look around in the hope of securing some of the American material which is said to be coming forward later. In the matter of ship and boiler plates the demand continues to be far ahead of the supply, and everything delivered goes rapidly into consumption, and the cry for more is general. Sectional material is somewhat scarce just now and the users of same are finding difficulty in securing sufficient for their immediate needs. The output, while large, does not seem large enough to meet the present demand. The amount of black steel sheets required by actual consumers makes up a very large tonnage and a constant pressure is maintained for supplies. Makers are still doing all in their power to keep all their regular customers going, but their efforts seem only to meet current requirements and arrears are general all round. There is plenty of new business on offer, but little is being accepted. The export trade in steel does not amount to anything much in the way of tonnage. Prices keep strong.

Malleable Iron Trade.—The prevailing conditions in the West of Scotland malleable iron trade have varied little, and the usual scramble for deliveries continues. The orders on hand are being slowly worked off, but there are plenty of buyers in the market eager enough to fix up considerable quantities well ahead, although their number is perhaps not quite so large as recently. Prices are firm, and the basis quotation for "crown" bars is about 30*l.* per ton, net, at works, Glasgow.

Scotch Pig-Iron Trade.—The scarcity of Scotch hematite iron and No. 1 foundry iron is still very pronounced, and in the case of the latter at any rate is practically unprocurable, except by those who have been regular customers. These have themselves no little difficulty in securing enough to keep them moving owing to the reduced output. The scarcity is rather a serious matter, as so much iron is required at the present time. The American pig-iron which has been arriving has helped things slightly, but not to any very great extent. In the case of hematite there is a very high consumption at all the local steel works, and each week's output gets distributed around the usual customers. Prices continue very firm.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The scheme of the Government for the decentralisation of control in the coal industry came into operation on Monday last. The proposals involve a definite limitation in exports, and collieries have received allocations of the quantity which will be available for shipment abroad each week. These allocations may be exceeded or decreased in any particular week, but must be adhered to over fortnightly periods. Thus a colliery may carry balances over from the first week in a fortnight to the next week, or *vice versa*. The quantity available for export, however, is much smaller than was previously the case and much apprehension is felt locally as to whether the scheme will prove practicable, for it is feared that the conservation of much larger supplies for home consumption will result in temporary stoppages at collieries as transport facilities are inadequate to meet the demand, and the definite limitation of shipments foreign will lead to detention of trucks at the docks. Though collieries have more freedom in respect to inland business the export trade is under closer control than ever, for not a pound of coal can be sent out of the country until it is released by the committees responsible for the distribution of outputs, and numerous instances could be cited of collieries having coal standing on the docks and steamers ready to load which are unable to load because the authorities refuse to release the coal, with the result that colliery wagons which are so much needed are kept on the dock side instead of being emptied and promptly returned to the pits. Some idea of the restraint on the export trade will be gathered from the fact that of the 1,750,000 tons of coal to be shipped abroad per month, France is to be supplied with 750,000 tons compared with a monthly quantity of 1,065,000 tons in 1913, Italy with 350,000 tons against 804,000 tons, British depots and Egypt with 250,000 tons against 416,000 tons, South America with 80,000 tons against 575,000 tons, Norway with 60,000 tons against 191,000 tons, Sweden 60,000 tons against 380,000 tons, Denmark 60,000 tons against 253,000 tons, Spain 40,000 tons against 304,000 tons, and other destinations with 100,000 tons, from the whole of the United Kingdom. Business on the coal market has been brought to an almost complete standstill and shippers experience great difficulty in making up even small cargoes because the exports of individual collieries have been reduced to such insignificant proportions. The position has been further complicated by a strike of some 15,000 miners in the Rhymney Valley in connection with the "drawing of timber," and a stoppage of the whole coalfield is threatened. Under the new scheme foreign exports from South Wales are restricted to about 270,000 tons per week, or about 100,000 tons less than in the first two months of the year.

The Iron and Steel Trades.—General conditions show no alteration to those in evidence a week ago. The continued fall in the price of tin has caused buyers of tin plates to hold off, but as makers on the whole were fully booked up with contracts, commitment prices, though on the easy side, have not undergone any material change. For prompt delivery the basis plates have realised 73*s.* per box, and current quotations range from 70*s.* to 74*s.* Galvanised sheets were unaltered at 55*l.* for 24-gauge corrugateds and tin and sheet bars were round 30*l.* per ton.

UNIVERSITY OF BRISTOL.—The Faculty of Engineering of the University of Bristol has published a record of the occupations of former students; it takes up 36 pages, and many important posts are mentioned therein.

BRITISH PRODUCTION OF PIG-IRON AND STEEL.—The production of pig-iron in April amounted to 671,000 tons, of which 246,000 tons were hematite, 226,000 tons basic and the remainder forge, foundry and other qualities. The production of steel ingots and castings amounted to 793,000 tons. The following figures give the production for the last six months:—

	Pig-Iron. Tons.	Steel Ingots and Castings. Tons.
November, 1919 ...	624,000	695,000
December, 1919 ...	632,000	692,000
January, 1920	665,000	754,000
February, 1920 ...	645,000	798,000
March, 1920	699,000	840,000
April, 1920	671,000	793,000

REPORTS OF THE UNITED STATES NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.—Report No. 50, recently issued by the United States National Advisory Committee for Aeronautics, bears the title "Calculation of Low-Pressure Indicator Diagrams," and contains a theoretical study of the pressure variations in an internal-combustion engine during the low-pressure part of the cycle. The contents of another report, numbered 69, and entitled "A Study of Airplane Ranges and Useful Loads," are sufficiently indicated by the title. Report No. 72 relates to "Wind Tunnel Balances," and is divided into four parts, the first of which gives a detailed description of a balance of the N.P.L. type, designed for the wind tunnel at Langley Field, Va., U.S.A. The second part of this report treats of the sensitivity of this type of balance, the means provided for adjusting sensitivity, and the effect on sensitivity of the rolling and yawing moments and cross-wind force which appear when the oscillations of the balance throw the plane of symmetry of the model out of line with the relative wind. Part three discusses the possible errors of the N.P.L. balance, while the remaining part contains brief descriptions of the Eiffel, St. Cyr, Curtiss two-axis, and Wright balances. A separate report, numbered 74, gives a full description and discussion of the best methods to be employed in constructing model aeroplanes and parts for testing in the wind tunnel, and may be regarded as a handbook on a subject upon which but little has been published hitherto. This report is entitled "Construction of Models for Tests in Wind Tunnels," and it can be obtained, together with any, or all, of those above-mentioned, on application to the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A.

NOTICES OF MEETINGS.

THE INSTITUTE OF TRANSPORT.—Monday, June 14, at the Institution of Civil Engineers, Great George-street, Westminster; a paper will be read on "To-day's Problems in Port Administration," by Sir Joseph G. Broodbank. The chair will be taken at 5.30 p.m. by Sir Sam Fay, a vice-president of the Institute.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, June 16, at 6 p.m., at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. Discussion on the following: (1) The paper read by Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., before the Royal Society of Arts, entitled "Distribution of Heat, Light and Motive Power by Gas and Electricity"; (*b*) The "Report on the Coal-Gas and Electrical Supply Industries of the United Kingdom to the President of the Institution of Gas Engineers," by Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., Professor Arthur Smithells, C.M.G., F.R.S., and Professor J. W. Cobb, C.B.E., B.Sc., F.I.C.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 16, at 5 p.m., in the Rooms of the Royal Astronomical Society, Burlington House, Piccadilly. Papers to be read: (1) "The Ether Differential Radiometer," by Mr. W. H. Dines, F.R.S., F.R.Met.Soc.; (2) "The Composition, Ionisation and Viscosity of the Atmosphere at Great Heights," by Professor S. Chapman, F.R.S., F.R.Met.Soc., and Mr. E. A. Milne, B.A.

THE ROYAL SOCIETY OF ARTS.—Friday, June 18, at 4.30 p.m., Indian Section. Sir George Birdwood Memorial Lecture, "The Enduring Power of Hinduism," by Sir Valentine Chirol. The Right Hon. Lord Meston, K.C.S.I., LL.D., will preside.

BRITISH CONTROL OF FUEL OIL.—In a recent address, Mr. Paul Foley, Director of Operations, United States Shipping Board, says *Power*, New York, stated that although 65 per cent. of the world's current petroleum production is being drawn from the United States, practically all the visible future production is under the control of Great Britain. Furthermore, although production in the United States is available to all other nations on terms equal to those applicable to the States themselves, that under British control and located in the middle area of the world is available only to British nationals. The practical effect of these restrictions is that while British ships can secure fuel oil in United States and Carribbean ports on the same terms as those governing supplies to American ships and also obtain what they require overseas from the nearest producing field, American requirements overseas can be met only at British terms and must reflect the long haul from American and Mexican seaboards. "An important step in correcting this evil is that the United States should take advantage of the fact that the control which Great Britain enjoys has been attained by means of capital loaned by the United States Government. With this in mind the States should insist that the same principle of equal opportunity now extended to British nationals in American producing fields be extended to American nationals in British producing fields."

LEAD-COATED IRON.—Lead is the cheapest of the metals available for providing iron with a rust-proof coating, but it does not adhere well to the iron. In terne plate an alloy of 25 per cent. of tin with 75 per cent. of lead is used; but the tin became very scarce during the war and is always expensive. The Schoop process of spraying is hardly suitable for tonnage production. In looking for ways of improving the adhesion of lead, Charles Baskerville, of the College of the City of New York, first tried the patented process of Goodson who submits fused lead for several hours to intense alternating currents at low volts—without observing any improvement. Since the addition of antimony to lead prevents the shrinkage of the lead on solidifying, Baskerville then provided the iron with a preliminary coating of antimony before dipping it into the lead or a lead-antimony alloy containing 12·5 per cent. of antimony. How he produced the first preliminary coating he did not explain in the paper, which he read before the American Chemical society last year and which is published in *The Journal of Industrial and Engineering Chemistry* of February last. It is not quite clear either whether the dipping into the eutectic alloy mentioned requires any preliminary coating of the sheet metal with antimony. But he obtained some very good results with some 800 shingles, 9 in. by 10 in., of mild steel, and probably the process was generally worked as follows: The steel shingles were pickled in sulphuric acid, washed with water, thoroughly blackened by a solution of antimony chloride, washed again in water, and then passed through a zinc chloride flux into the molten alloy, finally to be quenched in oil. Most of the shingles stood the aerated-water test and other tests without rusting, but some were pitted; whenever rust developed, it showed first at the edges, and for this reason barbed wire should not be coated by this process, whilst smooth annealed wire takes a very good coating. On roofs such shingles, made by the National Lead Company, have been exposed for over three years without corroding; they, however, did not resist the sulphuric acid fumes in the air near an acid plant. When in good condition the shingles and the lead-coated metal in general may be bent, twisted and hammered. The lead weight is about 47 grammes (1½ ozs.) per square foot. Exterior coatings on iron pipes (for petroleum pipe lines) were not always sufficiently satisfactory to justify the additional expenditure—probably owing to the roughness of the pipes.

THE HAMWORTHY TWO-CYCLE OIL ENGINE.

(*For Description, see Page* 792.)

Fig. 1.

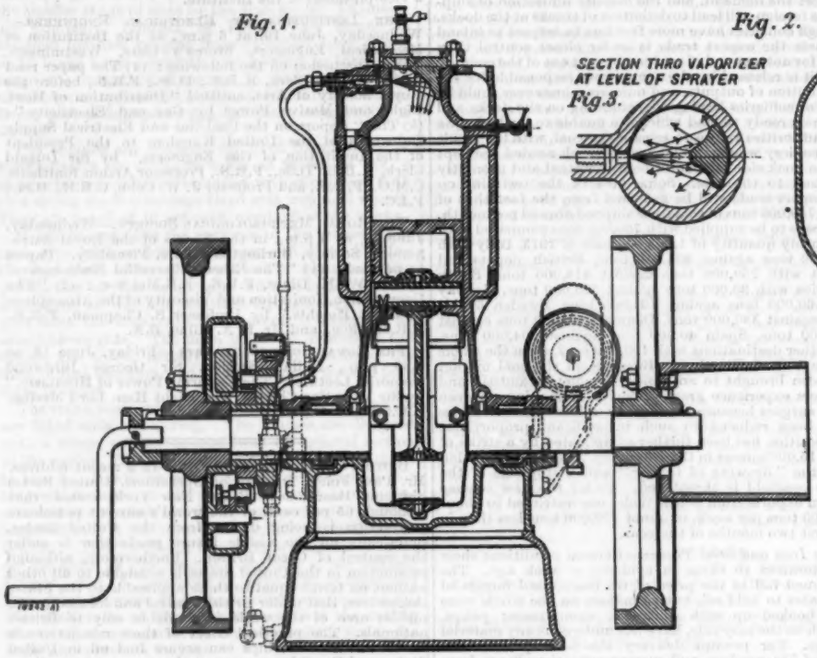
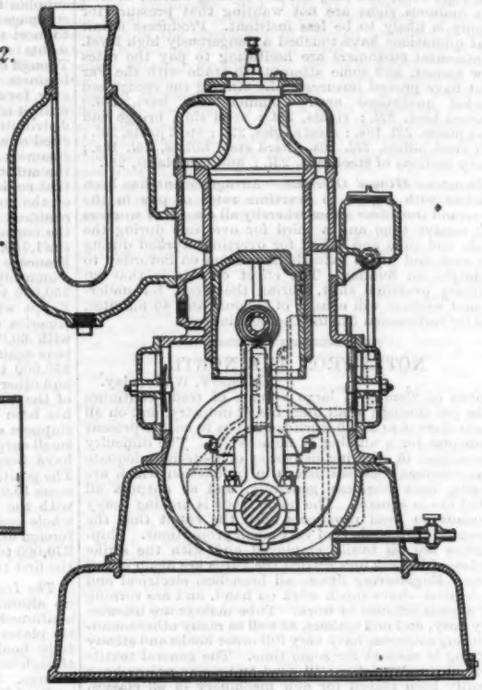


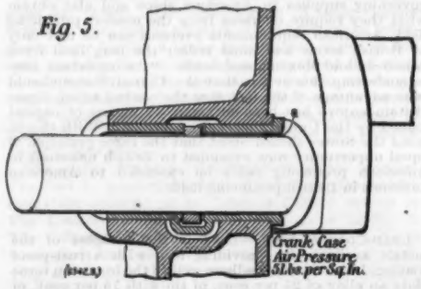
Fig. 2.



SECTION THRO VAPORIZER AT LEVEL OF SPRAYER

Fig. 3.

Fig. 5.



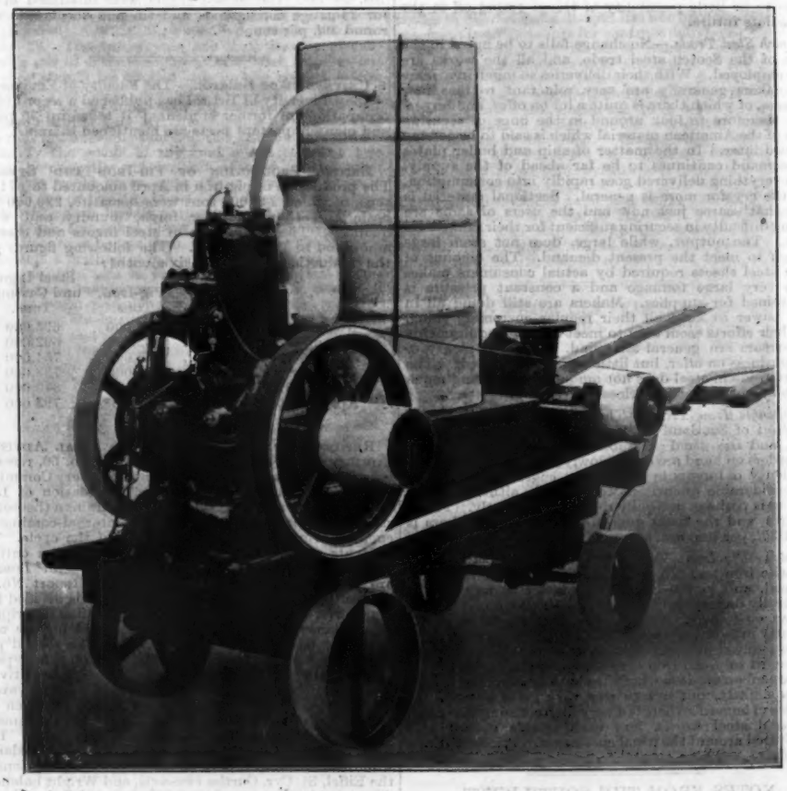


FIG. 4.

THE NEWCOMEN SOCIETY.—A new society, with the above title, has been formed to encourage the study of the history of engineering and manufacturing industries—particularly in the United Kingdom. It is intended to disseminate historical information among its members by meetings, discussion, correspondence, and the circulation of original papers, and also by arranging visits to objects and places of interest. The society will also act as a channel of communication between members engaged in similar lines of study or research, and will assist them by indicating where information on particular subjects is to be found. Other objects of the society are to collect and preserve, or cause to be preserved either locally or nationally, examples, records, drawings and illustrations of engineering work and industrial processes, and to publish proceedings containing original memoirs and historical material not generally accessible. Membership is open to persons, of either sex, interested in the objects outlined above, and the annual subscription has been fixed, tentatively, at 1*l*. Mr. Arthur Titley, M.I.Mech.E., of Queen's College Chambers, Birmingham, is the president, and Mr. H. W. Dickinson, M.I.Mech.E., of the Science Museum, South Kensington, London, S.W. 7, is acting as honorary secretary and treasurer, *pro tem.*

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The first meeting of the North-East Coast Institution Panels for the Standardisation of Ships' Details was held in the rooms of the Institution on the 1st inst. The Institution states that a movement for the standardisation of ships' details has been on foot since 1917. The Institution's part in this movement first took public form in the discussion of a paper read before it by Mr. C. Waldie Cairns, in December, 1917, on "Some Insufficiently Considered Details of Ship Construction and Equipment" (see ENGINEERING, vol. cv, page 21). The direct result of the paper was the formation of a Ships' Fittings Committee of the Institution for preparing standards for all eligible details of ships' equipment, &c. The further work of the committee was suspended by the appearance upon the scene of the British Engineering Standards Association, which informed the Institution that it had under consideration the formulation of national standards for ships and ships' machinery details and would be glad of the Institution's co-operation. As the result of negotiations with the British Engineering Standards Association, the Institution's Ships' Fittings Committee has been replaced by the Institution's Panels above referred to, and the technical work involved in the standardisation of ships' details is being done by these and by similar panels appointed in the Clyde district.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS AT LINCOLN; THE ABBEY WORKS.

(*For Description, see Page* 778.)

FIG. 33. BAR PREPARATION SHOP.

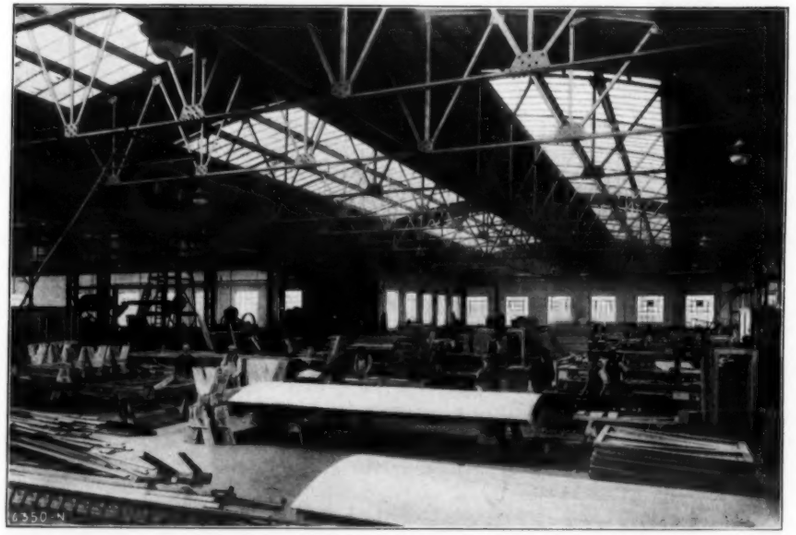


FIG. 34. SAW MILL.

FIG. 35. UNDER-FRAME SHOP.

FIG. 36. ERECTING SHOP.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS AT LINCOLN; THE CLAYTON FORGE.

(*For Description, see Page* 778.)

FIG. 37. BAY IN HEAVY STAMPING SHOP.

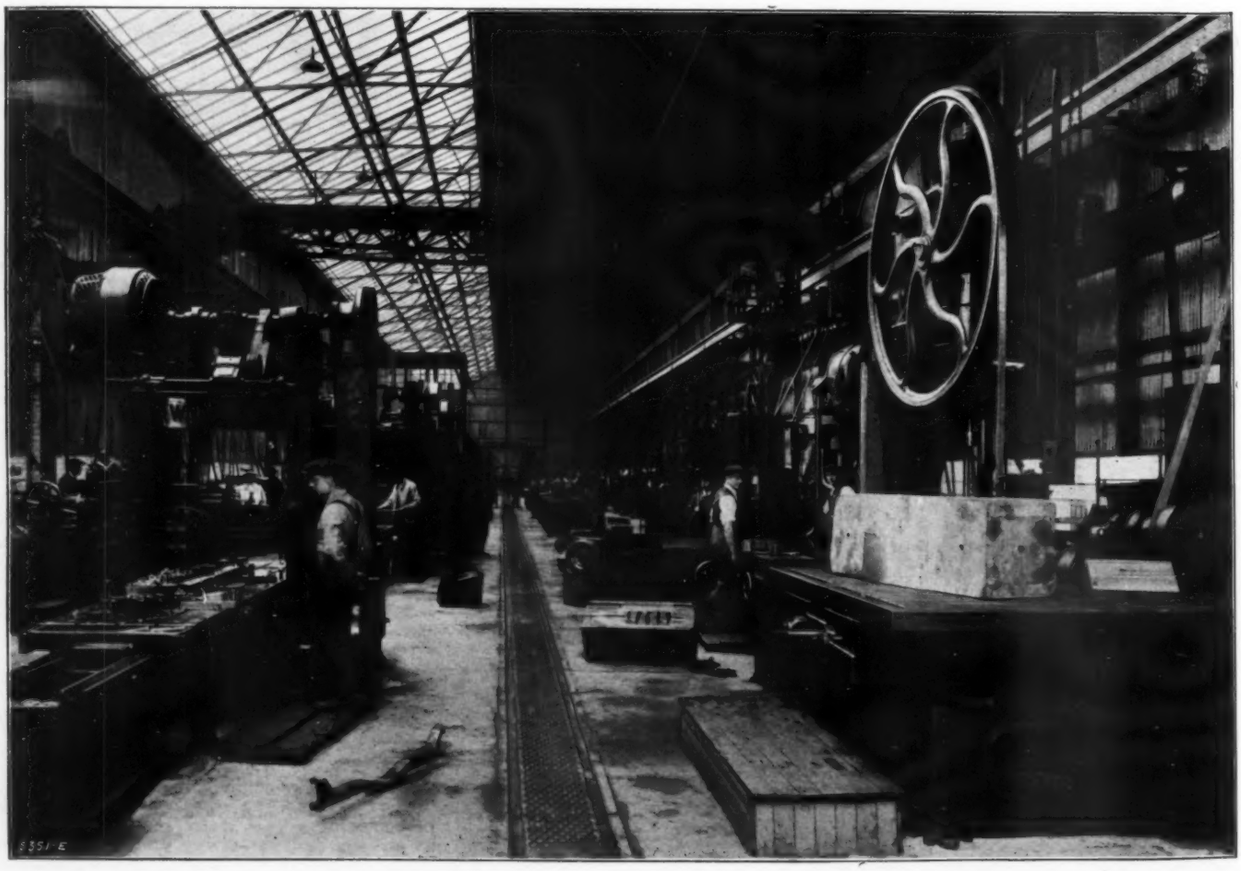


FIG. 38. BAY IN DIE-CUTTING SHOP.

FIVE-TON STEAM WAGON WITH SIDE TIPPING COMPARTMENTS.

CONSTRUCTED BY MESSRS. CLAYTON AND SHUTTLEWORTH, LIMITED, ENGINEERS, LINCOLN.

(*For Description, see Page* 778.)

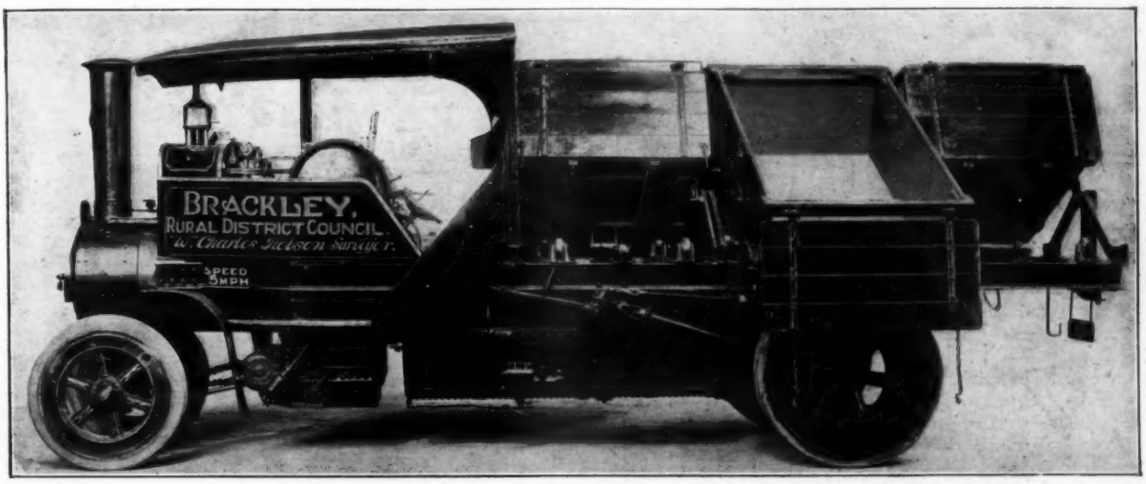


FIG. 39.

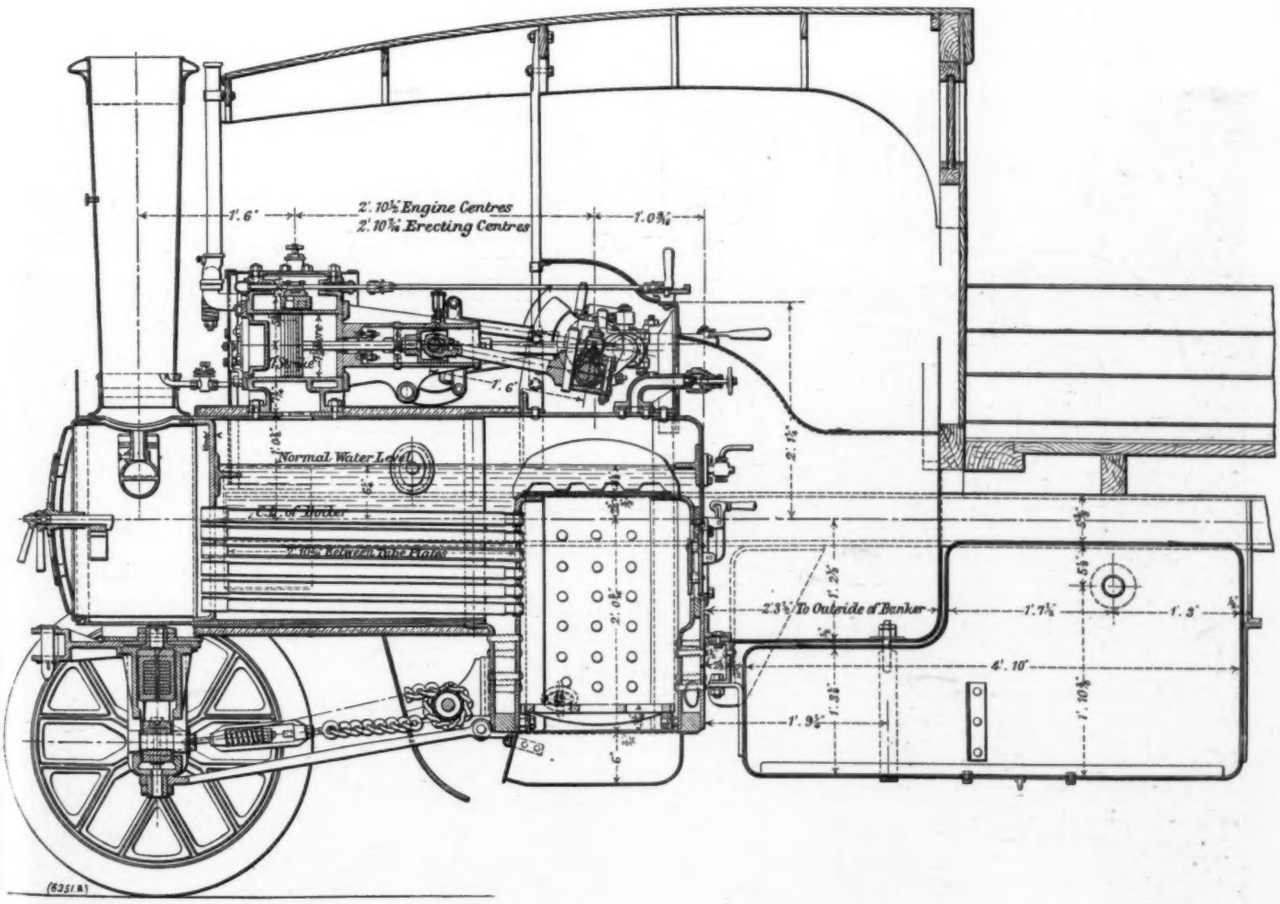


FIG. 40. GENERAL ARRANGEMENT OF ENGINE AND BOILER.

MAGNETIC REVERSE GEAR AND PETROL-PARAFFIN CARBURETTOR.

CONSTRUCTED BY THE WOLSELEY MOTORS LIMITED, BIRMINGHAM.

(*For Description, see Page* 786.)

Fig.1.

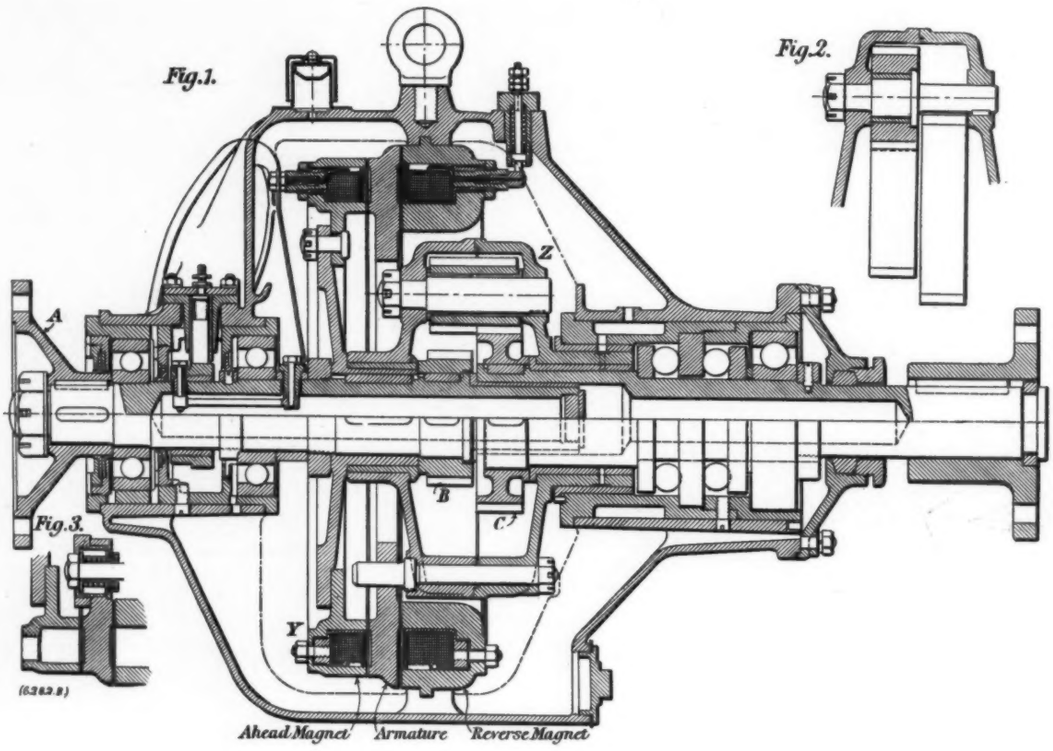


Fig.2.

Fig.3.

Fig.4.

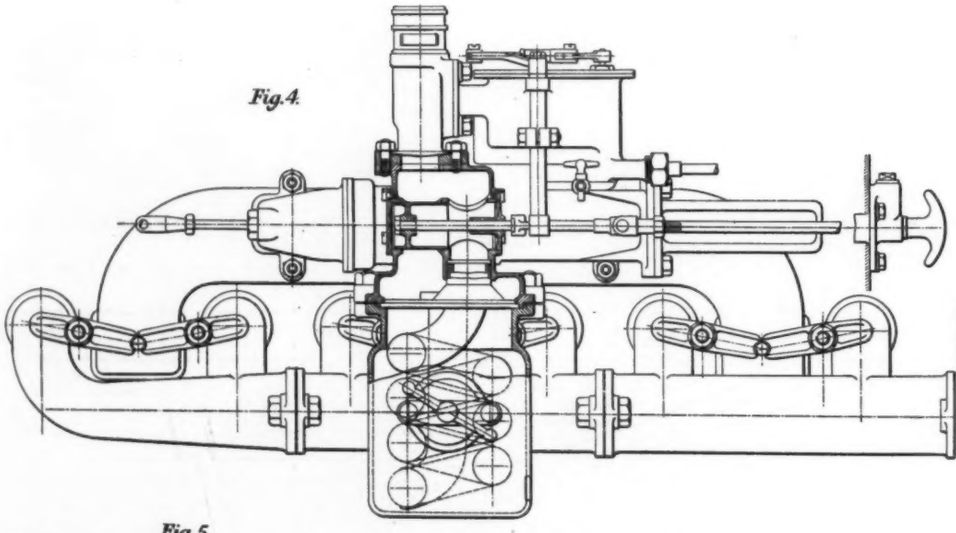


Fig.6.

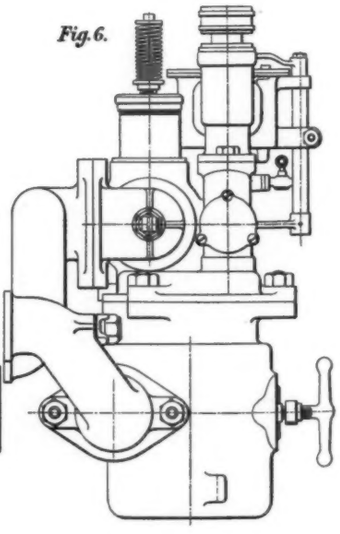
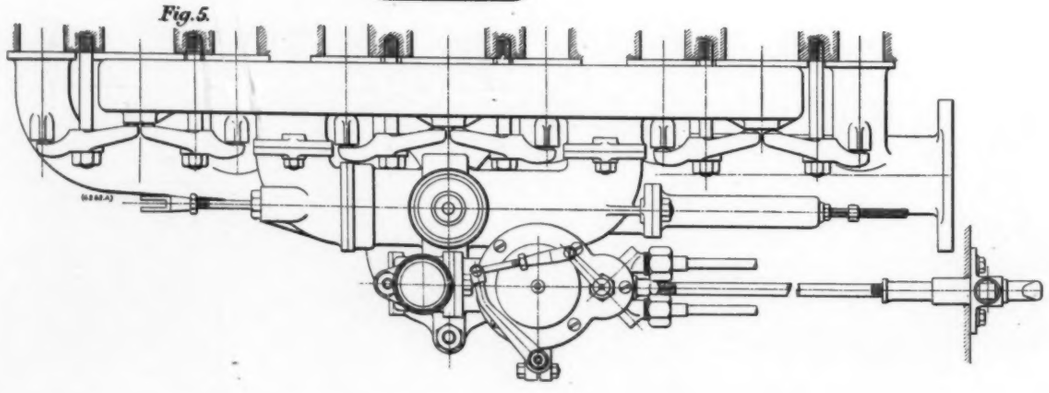


Fig.5.



(*To face page* 781.)

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A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 793.

ENGINEERING.

FRIDAY, JUNE 11, 1920.

MATHEMATICS FOR THE ENGINEER.

IN his famous article on the "Atom," published in the ninth edition of the Encyclopedia Brittanica, Clerk Maxwell notes that though the first exact notion of quantity attained by mankind was found in the consideration of number, which is essentially discontinuous in character, "the true direction of scientific progress was for many ages towards the recognition of the infinite divisibility of space and time." This was the line taken in the development of mathematics, which ensued on the revival of learning and to a preponderating degree the progress then made was due to the attempt to apply mathematics to problems in mechanics and physics. In such cases the functions presenting themselves could be represented by graphs, and were in general either continuous or capable of being separated into portions, each of which could be treated as definite and continuous. The methods of attack developed were accordingly founded largely on mechanical and physical intuition, which still remains the most potent instrument at the service of the investigator concerned in the mathematical treatment of natural phenomena. The establishment of the atomic theory made it evident that many of these phenomena were essentially discontinuous in character. The number of molecules, for example, in a mass of gas is necessarily a whole number, and thus it is from the standpoint of strict logic illegitimate to apply the calculus to the discussion of the properties of gases which must vary by definite units and not continuously.

During the last half-century or so, a change in point of view not dissimilar to the foregoing revolution in physics has taken place in connection with pure mathematics. Just as we now know that in Nature discontinuity is in reality the rule, and not the exception, so the pure mathematician informs us that continuous functions are the exception in mathematics, and that in general a function cannot be differentiated, and many cannot be represented by a graph.

What is of more importance still, is that the definitions and proofs of important theorems due to the geometrical and physical intuition of the older school of mathematicians are now declared to be hopelessly inadequate or wrong, and much ingenuity has been expended during the past few decades in what has been called the "arithmetisation of analysis." This procedure unfortunately from the standpoint of the investigator who desires to use mathematics as a tool for research in physics or engineering, has nothing whatever to do with the, to him, all essential problem of computing numerical results, but merely with restating and proving theorems in such a form that no logical inconsistency shall arise in applying them to discontinuous functions. This pursuit is undoubtedly a perfectly proper and legitimate one, fully as valuable and far more interesting than the study of the niceties of the Greek grammar. Exception may, however, well be taken to the claim made, that those who study mathematics with a view to its practical applications shall be compelled to study analysis along the same lines as he who means to pursue it for its own sake. Some twenty years ago the present writer chanced to mention to an eminent Cambridge professor of mathematics that he had been making use of a certain well-known treatise on spherical harmonics. The professor was horrified to hear that this book should have fallen into into the hands of an engineer, because "the proofs were not sound," and exactly the same observation was made last year when the writer was in conversation with another Cambridge professor. Both these mathematicians maintained that rather than use mathematical text books in which the proofs proffered were based on geometrical and physical intuition the engineer should content himself with mere tables of formulas and results. Had this observation been made by men of less eminence we should have had no hesitation in qualifying it as unintelligent; but, at any rate, the remark shows a deplorable failure to appreciate the conditions in which practical problems present themselves to the investigator.

In work of any real originality it becomes necessary to adapt the mathematical tool to the problem in hand. The most powerful methods of attack are normally based upon just such geometrical and physical intuitions as were fostered by the older methods of teaching the calculus and which are denounced by the modern devotee of pure mathematics. It is not possible in work of this character for the investigator to pick up a book of mere mathematical formulas, and by selecting one, appropriate to the problem in hand, obtain the solution required by giving the proper numerical values to the coefficients. There never has been a research of real originality effected by such methods, and it may safely be said that there never will be. To render any essentially new problem in engineering or physics tractable to mathematical attack it is necessary to ponder long and deeply the special physical and mechanical peculiarities that may be involved.

An excellent example of this procedure is provided by the manner in which Osborne Reynolds founded the theory of lubrication by suitably modifying the equations for the flow of a viscous fluid. These equations, as established by Stokes, were in such a form as to constitute a most indifferent tool for the attack of the problem in hand. Reynolds observed, however, that from physical considerations it was evident that certain quantities must be small, and by neglecting these he devised a theory of lubrication which, as further developed and applied practically by Michell, rendered possible the construction of H.M.S. Hood. This feat, naval architects declare, was rendered practicable solely by the adoption of the Michell block. Each shaft transmits 36,000 h.p., and the thrust is taken on a single collar. An equivalent block of the old type would have been 25 ft. long, and only a very sanguine man would anticipate that such a block would work satisfactorily.

As stated, Osborne Reynolds solved the problem by treating certain quantities as small. As Professor A. N. Whitehead points out in his "Introduction to Mathematics," the aim of the pure mathematician has been to banish from his subject such vague terms as "small" and "gradually." It is, however, these admittedly somewhat hazy concepts which constitute the most valuable tools of the applied mathematician. The whole mathematical theory of elasticity, for instance, has been built up on the hypothesis that small quantities of the second order can be neglected. The term, no doubt, is vague, but the concept, vague as it is, has proved and continues to prove of the utmost practical value. The worker who wishes to use mathematics as a tool for investigating probems in physics or engineering has a very effective safeguard against important error in that his end and aim is to obtain a definite numerical result. Hence the fact that cases can be conceived in which $\frac{\partial^2 u}{\partial x \partial y}$ has not the same numerical value as $\frac{\partial^2 u}{\partial y \partial x}$ is merely an

interesting curiosity, unlikely to have a bearing on any of the problems with which he may concern himself. Should such an event perchance arise the anomaly will be disclosed by the arithmetic. It may be added that in a great many cases in which differential equations have to be dealt with, a solution which satisfies the boundary conditions will not be seriously wrong arithmetically, even if it satisfies the original equations but roughly. A notable example of this is afforded by Airey's discussion of the stresses in a heavy beam.

The task that the pure mathematician has undertaken of arithmetising analysis, is from the point of view of the engineer far from a step in advance. Where discontinuities are met with in Nature, the problem is either wholly intractable to mathematical treatment, or the conditions are such that the real discontinuity can be neglected and the properties represented by continuous functions having what Professor Whitehead calls "convenient" characteristics. This has been the case in connection with the kinetic theory of gases, where the theory of probability enables reliable numerical calculations to be made as to phenomena which are known to be really discontinuous in character. In other cases, the theory of probability provides no such assistance, and the phenomenon is quite incapable of mathematical representation. For example, as Osborne Reynolds showed, the head lost by water in flowing through a smooth pipe can be calculated so long as the velocity lies below a certain critical value, and again when it lies above another critical value. Between these critical limits, however, there is no definite relationship between the velocity of flow and the head expended in maintaining it. Repeat experiments yield widely discrepant results, and no amount of study of the mathematics of discontinuous functions would be of the slightest help to the engineer.

A similar kind of discontinuity is met in experiments on the air pressure on a plane inclined at different angles to the air current. For inclinations lying between 0 deg. and, say, 16 deg., there is a perfectly definite relationship between the inclination and the pressure, and again there is similarly definite relationship between these two quantities when the inclination lies between, say, 30 deg. and 90 deg. For inclinations between 16 deg. and 30 deg., however, repeat experiments may yield widely discrepant results, and the phenomena is no longer capable of treatment by mathematical methods. Hence in practical applications it may be stated that we are generally concerned only with the mathematics of continuous functions free from singularities of a high order. In fact, if an experimental curve should indicate a sharp cusp, the observer would suspect that his apparatus was affected by some error, and a further study of the phenomenon in the region of this cusp would almost certainly show either that some slip had been made or that the engineer was confronted with "critical" conditions such as we have illustrated above, and thus quite intractable to useful mathematical discussion.

In short, to the student who desires to use mathematics as a tool for engineering research the old proofs of, say, Taylor's theorem, which Professor Whitehead states have been shown to be unsound, are perfectly satisfactory, since to him mathematics is not the art of drawing necessary conclusions from data at once both complete and accurate, but merely of a tool for extracting from data necessarily imperfect, substantially correct numerical results. Here, again the word substantially is no doubt vague, but from the standpoint with which we are here concerned this is an advantage rather than a drawback. It may in some cases imply a result accurate to within $\frac{1}{10}$ per cent., whilst in other cases an estimate within an error of 20 per cent. may be admissible. In the early experiments on wireless telegraphy across the Atlantic, for example, Marconi would have considered himself lucky if he could have framed a mathematical theory which would have enabled him to predict the plant required within a margin of even 30 per cent.

Of course it may be urged as an analogy that a chemist who is trained merely in applied chemistry is a very poor chemist, but the analogy does not hold. The mathematician, in urging the engineer to dispense with proofs based on geometrical and mechanical intuition is urging him to abandon practice in the very methods which are alone likely to yield him assistance in applying mathematical methods to the solution of the problems that may confront him in practice. For this reason we are convinced that text books on the calculus for engineers should be based rather on the doctrine of infinitesimals than on that of limits or of limiting values. In fact, as Professor Whitehead points out in another connection, "The instinct of trained observers, and their sense of curiosity, due to the fact that they are obviously getting at something, are far safer guides" than the "external criticism" which may characterise the methods used as logically unsound. Indeed, logic pure and simple is nearly as indifferent a guide in mathematical physics as it is in social and economic questions.

Some years ago there was a strong movement in favour of teaching what was called practical mathematics. In so far as this teaching was devoted to showing the bearing of mathematics on engineering matters, the movement was to be welcomed, but unfortunately, in some cases the text books issued on the subject were largely occupied with the setting forth of simple methods of attacking selected problems and applicable to these particular problems only. One well-known engineer who received his early mathematical training under the direction of one of the principal exponents of this system has stated that he has never been able to make any practical use of the mathematics thus taught, whilst what he subsequently acquired by the methods of the ordinary text books then in vogue had proved of the greatest utility. The opposite side of the picture is told by another engineer who gained his mathematical knowledge in one of the most "rigid" mathematical schools in the country. He observed that it took him quite a long time after going back to the work shops and drawing office to realise that it was safe to expand, by Taylor's series, such functions as were presented to him in his electrical investigations.

STATE ELECTRIC POWER CONTROL IN SPAIN.

LIKE other countries Spain has of late seriously had to consider the problem of her natural power resources, and it has done so on a broad national basis. Spain possesses already some important hydro-electric power plants; they are situated mainly in the northern regions, on the southern slopes of the Pyrenees and on the Ebro, and in the industrial centres of Madrid, Valencia and a few other districts. In the Pyrenees and in the centre, south-east from Madrid, electric power is transmitted over distances of more than 300 km. Though the importance of these power plants, some of which were remarkable in the days of their erection, may possibly be overrated in other countries, enough had certainly been achieved in Spain to demonstrate the great advantages and possibilities of electric power distribution, and the project which is at present under discussion in Spain seems to go further in a judicious nationalisation of the country's power resources, water and coal, than schemes have gone elsewhere. The whole country is to be encircled and traversed by a system of electric transmission lines, and the generation and supply of electricity is to be put under State control without undue restriction of private enterprise. It is a big scheme for a country, one and a half times as large as the United Kingdom, with less than half its population, 21,000,000 against 46,000,000. The Kingdom of Spain, apart from the relatively small Mediterranean Islands, forms a big continental square, a considerable portion of which is of plateau character with a severe continental climate and a very sparse population. Both water power and coal are concentrated in the north and are found in more isolated spots dotted all over the kingdom; the scheme is thus far bolder than it would be for our industrially highly-developed insular country, the midland counties of which are not really far from the sea and the natural resources of which are more evenly distributed.

In autumn, 1918, the Government of Spain appointed a Permanent Spanish Electricity Commission to study the problem of a State network for the distribution of electric power and to report upon the probability and desirability of such a project, its compass, costs, State dues, the unification of electric systems and upon the outlines of a Bill to be submitted to the Cortes. Within a year the Commission presented a project to the Ministerio de Fomento, which corresponds more or less to the Board of Trade. That report was not shelved. The Commissioners did not doubt the possibility of some such scheme, and considered it desirable, for various reasons. The development of the hydro-electric industries would be promoted; plants in existence could be extended to their full capacity; by separating generation, transmission and distribution, and by reducing the number of transmission lines a saving could be effected both in installation and in maintenance; small and remote water powers and small fields of inferior coal could best be utilised; the State would be able to command its own power for the electric working of the railways and other purposes, and industry would profit in general, and would be developed in districts where the actual power difficulties hardly justify encouragement. One feature, of no striking significance at first glance, favours the suggestion of one network covering the whole country. In the northern mountains high water occurs in spring and summer, in the rest of the country and especially in the mountains of the south high water falls in the winter; thus the north and south may assist one another during the periods of water scarcity, though the distances involved are great.

Considering in its general estimate only power sources of more than 20,000 kw., the Commission averages the available power at 2,000,000 kw. One-quarter of the total would come from the Pyrenees; nearly 200,000 kw. more can be furnished by the Ebro River and its tributaries both from the Pyrenees on the left and from the right. The mountains of the north-western and northern provinces—Galicia, Asturias, Leon—can yield another 150,000 kw. With its tributaries the Duero River, which forms the frontier between Spain and Portugal for part of its course and enters the Atlantic below Oporto, is to supply 300,000 kw., the Tejo 160,000 kw.; the rivers of the south and of other parts of Spain are individually less important, but they will together swell the total of available power. The contemplated network of electric transmission lines will form an irregular quadrangle or hexagon with more or less pronounced corners at Oviedo (in Asturias), Barcelona, Valencia, Granada, Sevilla, Alcantara (on the Tejo); a Y branch apart is to extend north-westward from the main polygon, over to Coruna and Vigo, and radial lines are to connect Madrid, which lies in the centre of the peninsula, to the corners mentioned and also to Tremp, Tortoga and Salamanca. Apart from the "Y" referred to, the straight main lines will follow the outlines of the peninsula, avoiding the coastal irregularities. The northern line is to proceed from Oviedo to Santander, Bilboa, Pamplona, Tremp and Barcelona; the eastern branch is to pass near Tarragona to Tortoga and Valencia, and thence straight on to Granada, Alcoy and the Alicante district being reached by a branch. Granada is to be joined to Sevilla, and from Sevilla the line will go north near Badajoz and the Portuguese frontier, and *via* Alcantara back to Oviedo. The length of the main transmission lines will be 4,800 km. (about 3,000 miles), but extensions will be necessary.

The question of current system and tension does not appear to have troubled the Spanish Commission much, because practically all the actual plants of Spain work with three-phase currents at 50 periods. Within the past few years, of course, the critics of three-phase distribution have everywhere been making converts, and it will be interesting to watch whether the Spanish experts will adhere to their adhesion to the three-phase system for general long-distance transmission, especially as electric railway working is also projected. For the present, however, the decision is for three-phase overhead conductors of 3 mm. by 100 mm., 3 mm. by 75 mm. and 3 mm. by 50 mm. sections, to carry currents at 120,000 volts. The stoutest conductors are proposed for the most important

lines including those connecting Tremp in the Pyrenees with the northern power stations, and with Madrid. All the lines are to be double, on the same masts, and the whole line network is to cost about 130,000,000 pesetas (francs), an estimate which will probably be exceeded. The actual hydro-electric power of 300,000 kw. is to be doubled in the first instance, and we may expect an enlargement rather than a diminution of the project which at present does not provide for the provision of further water power by the creation of large storage basins with the aid of dams.

We had to characterise the wide scope of the project before passing to the most interesting features, the regulation of the relations between the State and public as to the generation and supply of electric power. Those rules have so far only been drafted in outline. The leading principle is that the State will take supreme control in order to help industrial development and to guard the interests of the general public. It is not intended to take current generation out of private hands or to create a State monopoly. The State is going to undertake the construction, maintenance and control of the power transmission network, and the Ministerio de Fomento will fix the prices at which energy is to be fed into the mains and to be withdrawn. Those terms will be subject to adjustment in the different districts. The charge for current supply will in any case depend upon the capital invested and the expenditure for maintenance and control. A consumer claiming the full power available—apart from exceptional conditions—will not be charged anything beyond this annual fixed sum. When a firm or private individual shares the generation or consumption with others, the Ministry is to fix the terms so as to balance the consumption against production. Concerns which by drawing water power in their own interests impair the interests of the public, even if only because they do not command sufficient capital for efficient working, may be obliged to feed their current into the public mains and to draw their own needs from them. Plants already in existence may be expropriated or taken under control; new plants may be started while the project is assuming definite shape, but as soon as the current system has definitely been decided upon, any new plant under erection will have to conform to the system adopted. Everybody is entitled to claim current supply. Technical experts are to have a decisive vote in drawing up the regulations. If Spain pushes the legislative measures and the subsequent execution of the project as energetically as it has gone forward with the inquiry and the first report, other countries will keenly be interested in the development.

THE ENGINEER AND NOISE.

THERE is no branch of science which does not come within the purview of the engineer—physics, mechanics, chemistry, for instance, are all required in measure—depending upon the actual type of plant or product with which he is concerned. Of the three branches of physics—heat, light and sound—it is generally only to the first that much attention is given, whereas it is with sound primarily that these few notes deal.

The man in charge of any type of machinery knows well the beat of his engine and the sounds which are to be expected, and experience gives a well-attuned ear for discerning any unusual sound indicating untoward circumstances or faulty operation. In the workshops noise cannot but detract from efficiency, certain noises having notably greater influence in this respect than others. It has been stated, for instance, that with certain types of marine machinery, their noisy operation leads to inefficient service of the *personnel* in charge. A number of examples could be given where noise has been an important and even a determining factor.

When gearing was first introduced in marine equipments, between the turbine and the propeller, it was thought that the sound of the gear would be a distinct disadvantage to this type of machinery, especially in passenger vessels. These fears, however, did not materialise, although, if the gearing is not well and carefully machined and aligned, it is possible for such a note to be set up as to make conditions in the engine-room—anywhere in the vicinity of the gear-case—exceedingly unpleasant, until such time as the necessary wear takes place to give the requisite tooth bearing surface for sweet running. Good running mechanical gearing gives off a "hum" which is not in any way unpleasant and which on deck or in the cabins adjacent to the engine-room can only be very faintly heard, and does not compare unfavourably with the ordinary beat of the reciprocating steam engine.

Great as the advantages of the marine Diesel oil engine undoubtedly are, silence does not generally lie to its credit. The beat of the exhaust, the clatter of the valves and the other noises attendant upon the use of such prime movers result in a relatively noisy engine-room. In time, more attention will, undoubtedly, be given to this aspect of design, and there would seem to be no intrinsic reason why the Diesel oil engine should not compare favourably in this respect with the average reciprocating steam engine. Take, for instance, automobile practice and consider the great improvements in regard to the silent operation of the engine and transmission mechanisms which have been effected within the last ten years, culminating to-day in a complete power plant which for silence, and refined operation, leaves little room for improvement. In this class of work, of course, there is no doubt that the introduction of the sleeve valve engine had a very distinct influence, and, but for the ensuing competition to meet the demand for a refined product, the average poppet valve engine might not have reached to-day the present stage of development. The "Silent Knight" engine, as it was then known, set a standard to which designers of the ordinary type of engine had necessarily to work.

Coming back to marine installations, with the average four-stroke cycle Diesel engine, what are the principal causes of noisy operation? They may briefly be stated as follows:—

1. The induction air being drawn into the main cylinders through the intake pipes.
2. The cylinder head valves, on closing, hitting their seats and, on opening, the contact of the cam with the roller.
3. The exhaust leaving the cylinder entering into the exhaust pipe, and from the exhaust pipe passing into the atmosphere.
4. The whistle of any gas or air leakage past the main piston rings.
5. The hammer action of any pumps or of their valves.
6. The natural rumble of an engine in motion.
7. The noise of the gearing driving the valve shaft, and other parts so driven.

These are given probably in the order of their importance, and they may be examined singly.

Induction may be silenced by joining up the inlets to the various cylinders by a common suction pipe and leading this pipe to a suitable part of the engine-room to ensure the relatively silent intake of dry, cool air. This system, furthermore, is to be commended as probably giving a higher efficiency of induction than individual pipes to each cylinder, and certainly has a very considerable influence in silencing this operation. The hammering of the cylinder head valves on their seats cannot entirely be avoided; there must be clearance between the roller and its cam; therefore, on closing, the valve will strike the seat with a certain velocity, and similarly on opening the cam will strike the roller. This velocity can, of course, be reduced by altering the cam shape, but it has been generally found by experience that such a course leads to a disproportionate loss of volumetric efficiency. The design, however, can ensure that the moving mass arrested when the valve strikes the seat, is a minimum, and that the weight of valve gear attached to the valve is reduced as much as possible to this end. With certain designs of valve gear, not only is the weight of the valve itself to be considered, but a certain amount of valve gear is so attached thereto that this weight must be added to the weight of the valve when calculating the mass effect. In the engine-room the exhaust from the main cylinders causes very slight noise, and can only be silenced by water-jacketting and lagging the conducting pipes. Where the exhaust passes to the atmosphere, whether in a funnel or not, the question of silence is difficult of solution, but calls for special attention, as in a number of Diesel engine driven ships this continuous beating sound is unpleasant. By means of expansion chambers in the exhaust line between the engine and the outlet to the atmosphere, and by ensuring that such noise as does take place at the exit is not intensified by structures which can give rise to "drumming": improvements can often be made.

Piston-ring leakage should not occur to any appreciable extent, and it is desirable that the bottom sides of the cylinders should be closed in with handy doors for ready access, and that these spaces should be ventilated. It has become more general practice now to drive separately the necessary pumps, such as those for cooling water and lubricating oil, and rotary pumps which are notably silent, are gaining favour for most purposes. With a forced lubricated engine, the rumble is very small. It is caused by the displacement of air by the moving parts, and can only be reduced by having well-fitting access doors which do not rattle. Accurately-machined gearing running in an oil bath can be made remarkably silent.

If the various points to which attention has here been drawn are all considered in the design, the Diesel engine might be made to operate almost as silently as the average reciprocating steam engine. These points are raised with a view to encouraging designers to pay more attention to this subject of noise than has been the case in the past, since, from the standpoint of the operating engineer, the question is one of very considerable importance.

SIGNALLING BY INVISIBLE RAYS.

REMARKABLE feats in signalling by radiations outside the visible spectrum, both infra-red and ultraviolet, were accomplished during the war and, it must be added, still more strange things were attempted. It was found possible, for instance, to detect the presence of a living warm body, lying outside a trench in the dark, by the heat rays coming from it. But it was hardly possible, though repeatedly suggested, to discover the approach of a steamer or submarine, in a fog, by the thermal radiations from the smoke stack, since water vapour is opaque to infra-red radiations. The experiments on secret signalling were not initiated during the war. Books on the subject were published in 1913, by Ruhmer in Germany and by Miesmer in the United States. Since selenium was the most sensitive photoelectric substance then known, the first war experiments were conducted with selenium. But a search for photoelectric substances was made, notably by Case and by Coblentz and others* in the Bureau of Standards, and several sulphides were found promising. Some crystals of molybdenite, molybdenum sulphide, in particular proved up to 200 times as sensitive to heat rays as a gold leaf radiometer, an instrument of the bolometer type. Gold and platinum, blackened on the one side with soot, absorb all the incident radiations and are hence not suitable for the selective absorption of heat rays. The man in front of a trench is difficult to detect when he wears a heavy coat and covers his face, and a boat is not easily picked out from a shore background.

In the radiophonic signalling of the Bureau of Standards, so far as described by W. W. Coblentz last year before the American Physical Society [the full paper is not yet available], a pulsating electric current is produced by interposing a rotating sector-disc between the source of radiation and the receiver. The receiver consists of a crystal of molybdenite, a battery of dry cells, of about 50 volts, connected directly to the input terminals of a three-stage amplifier and a telephone; a concave mirror, silver on glass, of 16 cm. diameter and 50 cm. focal length, concentrates the radiations on the receiver. In the simpler field apparatus, the crystal mirror, disc and battery of six cells are mounted on a camera tripod.

In the experiments conducted at Washington, the transmitting and receiving stations were situated on the roofs of two houses, separated by three miles of houses and dusty streets. When the

* See ENGINEERING, August 24, 1917, page 206, and June 14, 1918, page 672.

radiation source was a 300-candle tungsten lamp mounted in a searchlight reflector, the transmission was very good at the full distance mentioned. With an automobile headlight of 20 candles in a metal reflector the signals were not always audible; sighted on a street lamp (80 candles) the apparatus still responded at a distance of half a mile, but the interposition of a glass screen and the exclusive use of the infra-red rays made the signals uncertain.

The full moon proved an excellent source of radiations; the intensity of the moonlight is estimated at 3×10^{-7} gramme-calorie per second. Since the sector disc used cut off about half of the light and reduced the time of exposure to about 1/500 second, the sector wheel radiophone could not be very efficient, and attempts were made to change the pitch in the telephone note, apparently on the heterodyne reception principle. It was observed that the high resistance then wanted in series with the crystal weakened the sounds, but when several crystal-receivers were connected in series to make up the resistance, better results were obtained. Considerable success was realised with potassium-hydride photoelectric cells of the gas-ionic type; but particulars were not communicated.

Professor R. W. Wood, of Baltimore, who came over to France, devised several other ingenious devices which he himself built up out of very primitive apparatus. When he demonstrated their use, so far as desirable, before the Physical Society of London,* he particularly spoke of a small lamp arranged in telescope fashion so as to give a very narrow, almost invisible, beam of light. To secure further secrecy he used a red light filter for day service and an ultraviolet filter for night service, the observer being correspondingly provided with a red screen (which shut out the daylight but transmitted the red beam) or with a fluorescent screen.

Another device was Professor Wood's lamp for naval convoy, radiating in all directions. This was a mercury lamp provided with a glass chimney permeable only to rays of λ 3,600; these are invisible, but they make the retina and lens of the eye fluoresce so that an observer at close quarters sees a haze, the so-called "lavender fog," filling his field of view; the rays could only be picked up by a receiver comprising a fluorescent screen. This instrument had a range of 4 miles (that previously described had a range of 6 miles) and by its aid ships were kept together without showing any light.

We need hardly say that similar devices were worked out in this country. It is to be hoped that the researches are proceeding, though they may remain for the present locked up in official archives. There is, however, little need for secret signalling in normal times. But astronomers, meteorologists and other scientists might find such instruments useful, and the thermo-ionic valve, which forms part of some of these devices, has sufficiently established the startling technical possibilities of observations apparently of purely theoretical interest.

NOTES.

GRADUATES.

THE North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne, is to be congratulated upon a novel scheme which it is inaugurating, namely, the compilation of "bibliographical papers," by members of its Graduate Section. The subjects selected for the session 1920–21 are "Internal-Combustion Engines for Marine Purposes" and "Strength of Ships," the object being to enable both engineering and shipbuilding students to compete. The "bibliographical papers" are not to be merely a bibliography, but papers frankly incorporating a bibliography with original comments by the authors. Besides providing an easy means of reference, which is—we may add—only a very secondary object of the competition, the work will prove greatly instructive to the candidates, by reason of the terms set down for the competition. The arrangement of the paper is left to the initiative of the graduate, and credit will be given for merit in this respect. The papers are to consist of a series of short reviews of works on the subjects referred to, the reviews to consist of an epitome of the works, the author adding such remarks as he may think fit. Each paper is also to include a short review by its author of the present state of development of the engineering, or the shipbuilding subjects dealt with. A list of the books and other publications reviewed is to be given as an appendix to each paper; the list to contain the titles of the works referred to, and the author's and publisher's names. In addition to treatises, text-books and other standard works, reference is to be made to the papers contained in the proceedings of scientific and technical institutions, to articles in the engineering press, pamphlets, &c. Works in the English language only are to be dealt with, but published translations are included, and credit will be given for reference to American and Colonial publications. The Institution has issued a copy of the regulations governing the competition. The task is one which the graduates, we are confident, will feel proud of undertaking for the honour attached to the enterprise and the information and experience they will gather from it, quite apart from the prizes (a first prize of 5*l.* and a second one of 3*l.*, both in the shape of books or instruments, for each subject) attached to the scheme.

AEROPLANE DESIGN RESOURCES.

Of the many regrettable features of the present stagnation in the aircraft industry, none appears to us to be more serious than the resulting reduction in the design resources of the country. At the termination of hostilities about ten large firms were employing design staffs in connection with aircraft manufacture, whereas, at the present time, the number of firms is certainly less than half that above mentioned, and the staffs employed have been, in all cases, considerably reduced. Some of the concerns took up aircraft work as a war expedient only, and their return to the manufacture of pre-war products is a natural consequence of the cessation in the demand for aircraft; but this is less disturbing than the fact that some, at least, of the pioneer aviation firms have found it necessary to seek other outlets for their activities. Attention to the matter was called by Mr. G. Holt Thomas in an important letter to *The Times* on Monday last, and the point was further emphasised by Major-General Seely in an address delivered at the inaugural public meeting of the Air League of the British Empire, held at the Mansion House on the following day. We have on many occasions urged the importance to the country of a well-developed aircraft industry, both from its commercial value in connection with rapid transport and from the point of view of national defence. In 1918, largely owing to the skill of our designers, we occupied the leading position in the world of aviation with heavier-than-air machines, and we were then in the best position, technically at all events, to lay the foundations of a flourishing aircraft industry. Since then public and official apathy, combined with unfavourable economic conditions, have allowed our resources to dwindle, while some other countries, notably Germany, according to Mr. Holt Thomas's information, have improved their position. To no other country can the future of aviation be of greater, or even of equal, importance than to the British Empire, and, for that reason, every possible effort should be made to improve the existing state of affairs. The establishment of mail services on routes which would show a considerable time saving is one way in which the industry might be assisted, and another is the purchase of machines for administrative and survey work in distant parts of the Empire, where other systems of transport are less highly developed than they are at home. These might be supplemented by the purchase and trial by the State of approved designs, and by awarding prizes as the result of competitive trials, one of which has already been arranged as announced on page 545 *ante*. The main desideratum at the moment, is, if possible, to prevent any further dispersal of design staffs, as the loss of the skill and experience of these men, and their possible transference to competing States, will certainly be felt in the struggle for aerial supremacy which is likely to ensue in the not far distant future. If the newly formed Air League can bring these facts home to the Government and the public they will certainly justify their existence and at the same time perform a valuable national service.

MEASURING THE VELOCITY OF PROJECTILES.

The new chronograph for proving-ground practice, which Paul E. Klopsteg, of the Leeds-Northrup Company, and Alfred L. Lovmis, late Major in the United States Ordnance Department, described before the Convention of the American Institute of Electrical Engineers in February last, is not of the Boulengé type. In these latter instruments the projectile opens an electric circuit by breaking the wires of a screen. In the new "Aberdeen chronograph"—so named after the proving ground at Aberdeen, Maryland, on which it was first used—the projectile closes the recording circuit by piercing two lead plates, previously insulated from each other, and it is claimed that the make-circuit arrangement renders the instrument more simple and more reliable than the Boulengé, and that the manufacture of a complete chronograph does not take more than one working day of 24 hours. The lead screen or contact target consists of two lead plates, 3 in. by 12 in., for the 3-in. gun, attached to the two faces of a larger sheet of paraffined paper; the projectile hits and pierces the front plate normally and closes the circuit as soon as it touches the back plate. The circuit, comprising a condenser and the primary of a transformer, leads to a spark point, mounted within a shallow aluminium drum which is rotated about its axis by a constant-speed motor. The speed control of this motor, which runs at 25 revolutions per second, is one of the essential features of the chronograph. A strip of paper, 500 mm. long, just fits into the drum, resting against the inner circumference; the paper is blue and thinly paraffined so that the spark passing between the terminal mentioned and the metal of the drum leaves a blue mark. Vertically above this sparking terminal are two more, joined to the circuits of a second and, if necessary, of a third lead. The contact targets are placed at distances apart of 50 ft., 150 ft. or 200 ft. (100 ft. for the first screen near the muzzle being customary for other chronographs). It is claimed that even with the two targets only 25 ft. apart, the Aberdeen chronograph gives records correct within 1 ft. or 2 ft. on velocities of 1,700 ft. per second. The records are checked by the aid of a fall apparatus which can readily be connected to the same sparking terminals. In this apparatus a steel ball rests on a lever which is knocked away when a weight is released; the release closes one circuit, the ball striking the base of the apparatus another. The height of fall and motor speed are so adjusted that normally the two spark marks should be exactly in the same vertical on the paper strip, the motor describing five revolutions during the period of the fall, 0·2 second; when the two marks are not in the same vertical, the motor speed is too great or too small. In general the check test need not be performed more than twice a day. The motor is started before firing; the velocity is directly determined by holding the strip (taken out) against a scale. The whole determination requires half a minute. The contact target has then to be taken down and to be refixed. An advantage of the reduced distance between the two targets is that the targets need not be fixed at inconvenient heights when the guns are elevated. The whole Aberdeen chronograph fits into a portable box; it was put into regular use in June, 1918.

CRYSTAL STRUCTURE AND THERMOCHEMISTRY.

Considerations of the forces which hold the atoms of crystals together in their space lattices suggest the existence of remarkably simple relations between the so-called lattice constants and thermochemical reactions. The atoms of alkali salts like rock salt seem to occupy alternating corners of the elementary cubes. According to a series of papers presented last year to the Deutsche Physikalische Gesellschaft by Max Born and A. Landé, the atoms of sodium and chlorine are ions simply bound together by electrostatic forces: forces of attraction between ions of opposite signs, these forces decreasing with the square of the distance as by Coulomb's law; and forces of repulsion between the shells of electrons surrounding the ions, decreasing as a much higher

* See ENGINEERING, May 2, 1919, page 582.

power, the tenth power in these cases, of the distance between the ionic centres. Since the atoms are rather crowded in crystals, these very unequal forces can balance one another. For the electrostatic work A to be done completely to dissociate one gramme molecule of the crystal into free gaseous ions, Born finds the formula $A = \frac{N\,a\,.\,(n-1)}{4\,\delta\,n}$; where N is Avogadro's constant, the number of molecules per cubic centimetre, $N = 6{\cdot}06 \times 10^{23}$; δ is the lattice constant, i.e., the distance between the centres of adjacent ions; a Madelung's lattice potential of electric attraction which merely depends upon the type of lattice; and n is connected with the charge of the electrons in the outermost shell of the respective atom. From compressibility tests n seems to have values lying between 7·7 and 9·6 for the alkali halides (halogen compounds); Born assumes the average value 9. For alkali halides the constant $a = 13{\cdot}94\,\epsilon^2$, where $\epsilon = 4{\cdot}774 \times 10^{-10}$ electrostatic unit, the elementary quantum. The lattice constant δ is a function of the density ρ of the crystal and of the atomic weights of the positive and negative ions μ_+ and μ_-. Expressing the A in kilogramme-calories K. Fajans (*Ibid.*) finds that for the alkali halides (except lithium salts which have other constants) $A = 545\,\sqrt[3]{\rho/(\mu_+ + \mu_-)}$. When the salts are dissolved in water, or when their aqueous solutions react with one another after the manner of KCl + LiBr = KBr + LiCl, the changes of A, the Δ A, represent the heat of the reaction which can be determined, and Fajans shows that these thermochemical data and the heats of hydration of the ions of hydrogen and the alkali metals and of calcium can be calculated, with very fair accuracy, from the formulæ of Born. Thus the lattice constants, found by X-ray analysis, and the molecular volume, involving the density and the atomic weights of the ions, suffice to calculate certain thermochemical data on the assumption that the atom has some kind of the structure of a Bohr-Sommerfeld atom. It should be pointed out that Born assumes the eight electrons of the outer shell of electrons not to be arranged in a plane ring, as Bohr does, but at the corners of a cube. We may mention in this connection that Harry Schmidt has recently investigated the equilibrium and stability conditions of electronic groupings (*Physikalische Zeitschrift*, October 1, 1919). Sir J. J. Thomson studied stable groupings of electrons, all in the same plane, in 1904, and has referred to them in his lectures on atomic structure. In recent years A. Haas investigated the possibilities of ionic arrangements in prisms, concentric polyhedra, pyramids and double pyramids. Further examining the conclusions of Haas by the stability principle of Lejeune-Dirichlet, Schmidt finds that there are a great many possible equilibrium positions, but that the stability condition reduces the numbers very much. Stability in fact seems to him possible only when rings of different numbers of electrons are arranged in parallel planes, symmetrically to an axis passing through the centre of the positive nucleus of Haas, which differs from Rutherford's nucleus.

LITERATURE.

Thermodynamics for Engineers. By J. A. EWING, K.C.B., F.R.S. Cambridge: At the University Press. 1920. [Price 30*s.* net.]

SIR J. A. EWING'S new treatise on thermodynamics meets a longfelt want. Since Rankine's textbook on the steam engine, we have had no authoritative work in English dealing with thermodynamics from the standpoint of the engineer. Moreover, Rankine's treatise was the work of a pioneer, and the pioneer is seldom lucky enough to hit upon the easiest route into the new territory he opens up, so that in general comparatively few are sufficiently gifted to follow his track unaided. Great advances have been effected in thermodynamics since the era when Kelvin, Joule and Rankine made their great discoveries, but the record of most of the work accomplished has appeared in publications not readily accessible to engineers, or in a form ill-adapted to their needs, thermodynamics being dealt with very much as if it were a branch of applied mathematics rather than a physical and experimental science. In contrast to this mode of treatment Sir J. Ewing does not give a general mathematical discussion of the equations of thermodynamics till his penultimate chapter. In the preceding chapters many of these equations are, it is true, made use of, but they are introduced as required by the problem in hand and with a full reference to their physical significance.

First principles are discussed in the opening chapter of the treatise which contains a very clear account of the more important properties of a perfect gas, and of what is meant by reversible actions. In this chapter the real meaning of the term "adiabatic" expansion is adequately explained, and the point is emphasised that to secure adiabatic expansion it is not sufficient to enclose the working fluid in a non-conducting envelope, but that none of the work of the expansion must be expended in producing eddies within the working fluid itself. In the past many textbook writers failed to make this clear, and this gave rise to a confusion of thought, which led in some cases to an attempt to establish a distinction between adiabatic and isentropic expansion. Carnot's reversible engine receives, of course, the treatment appropriate to its fundamental importance, but attention is drawn to the fact that there are other cycles than the Carnot cycle which have the same theoretical efficiency, notably, the cycle embodied in Stirling's regenerative air engine. The simpler forms of temperature entropy diagrams are also discussed in this chapter.

The second chapter of the volume is devoted to the properties of fluids. Possibly a caution should have been added here in connection with the distinction drawn between saturated and superheated steam. The statement is made (perfectly correctly) that steam in contact with water and in thermal equilibrium with it is necessarily saturated. Nevertheless engineers have often been puzzled by the persistence of droplets of water suspended in superheated steam. The fact is, however, that for the above statement to hold rigidly, it is necessary that the water should be pure. Water with salts dissolved in it has its vapour pressure reduced and droplets can accordingly persist in the presence of superheated steam. It was for this reason in his final series of experiments on the specific heat of steam in the neighbourhood of 100 deg. C., that Mr. Brinkworth used apparatus in which the glass tubing employed in the preliminary observations was replaced by tubes of pure tin. In this chapter some of the general mathematical equations of thermodynamics are necessarily introduced, and their physical import explained. Attention is drawn to the fact already known to engineers that Zeuner's equation for the adiabatic expansion of wet steam in thermal equilibrium is far from exact, and it is pointed out that such an expansion cannot be accurately represented by a formula of the type $p\,V^n = C$, though by a suitable choice of the value of the index the formula does, we think, yield results sufficiently exact for many practical ends.

The author defines "heat drop" in a manner which is, we think, unusual with engineers. The term is, we believe, generally taken as equivalent to what the author calls the adiabatic heat drop, whereas he defines it as the decrease in the total heat consequent on the expansion, whether this expansion be effected isentropically or with an efficiency of less than unity.

The third chapter in the book deals with the theory of the steam engine and introduces the usual temperature entropy diagram and the Mollier chart. A very clear and full description of the Rankine cycle is comprised in this chapter, and attention drawn to the fact that in strictness the expression for the efficiency of this cycle should contain a term expressing the work done in returning the feed to the boiler. It is further pointed out that the Rankine efficiency increases but slowly with increase of pressure, but rapidly with increase of vacuum. The loss of work due to the impossibility, in the case of reciprocating engines, of expanding steam down to the condenser pressure, is fully explained and illustrated by condition lines on the temperature-entropy chart.

The theory of refrigeration is most instructively discussed in Chapter IV. Here the working agent generally differs much from steam in its physical condition. The critical temperature for example is frequently exceeded, and the corresponding peculiarities in the entropy charts are carefully described. A valuable section of this chapter is that devoted to the discussion of the apparatus used for producing the extremely low temperatures by which air and the other so-called "permanent" gases can be liquefied. Particular interest attaches to the description of M. Claude's plant for the complete separation of oxygen and nitrogen by a process of fractional distillation. It would have been interesting to have had some statement as to the possible theoretical efficiency of the process. When gases are mixed together there is an increase of entropy, and work must accordingly be expended in subsequently separating them.

In discussing the theory of jets, Sir J. A. Ewing makes considerable use of Professor Callendar's paper contributed to the Proceedings of the Institution of Mechanical Engineers in 1915. In this paper the effect of supersaturation was accurately estimated, and accord established between theory and experiment. On the theory formerly in vogue, viz., that expansion took place in conditions of thermal equilibrium the weight of steam discharged from a nozzle was frequently found to be in excess of what was theoretically possible.

The great advantage which a turbine has over a reciprocator, in being able to utilise a high vacuum, is clearly brought out, and to this and its mechanical simplicity the writer attributes the rapid supersession of the older type of prime mover in power station practice. An additional reason is to be found in the possibility of constructing much larger units than are practicable in the case of reciprocators. As much as 75,000 h.p. has now been developed in a single steam turbine, and the space occupied is less than what would have been required for a reciprocator of one-tenth the capacity.

A particularly valuable chapter in the treatise under review is that dealing with the interna combustion engine. There has been a great increase in our knowledge of the properties of fluids at gas engine temperatures, since the joint discussion on the subject at the Leicester meeting of the British Association, in 1907, which led to the appointment of the Committee on Gaseous Explosions, whose work has thrown so much new light on the whole subject. At that date there was a widespread belief that the "air standard efficiency" proposed by a committee of the Institution of Civil Engineers in 1906, provided a reasonable standard of reference for comparing the performances of different internal-combustion engines. It has now been proved that gas engines have been working much more closely up to their theoretical possibilities than had previously been realised. All this is very clearly set forth in Sir J. A. Ewing's treatise and the author adopts, too, the now generally accepted opinion that dissociation has little to do with the great deficiency in the maximum pressure recorded. Possibly this view may require modification in the future if Professor Perrin's new theory as to the mechanics of dissociation be confirmed. Dissociation has in the past been attributed merely to the mutual jostling of the molecules, but in certain conditions the extent of the dissociation is found to be independent of the pressure of the dissociating gas, that is to say of the number of collisions in unit time. Professor Perrin accordingly has suggested that dissociation is solely due to radiation, the loops of electric force which constitute this, being capable of tearing the molecules apart. Dissociation on this view increases with increasing temperatures, solely because the radiation increases, but if, as is the case with gases in the act of combination, the radiation is in excess of that due to the temperature, the amount of dissociation produced should also be in excess of that naturally due to the temperature.

The loss in the ordinary gas engine cycle, which ensues from the failure to utilise the toe of the diagram, is clearly brought out by the author, and mention is made of Mr. Atkinson's ingenious attempts to avoid this waste, but there is no reference to the Humphrey pump, where the expansion is carried considerably further than was attempted by Mr. Atkinson.

The concluding portion of this chapter on internal-

combustion engines is devoted to an account of some of the principal results of the molecular theory of gases. This is further discussed in a separate appendix. The sketch of the kinetic theory thus provided is most welcome, and might with advantage have been very greatly extended. We regret to find no proof of Maxwell's partition theory. The author, like most of his predecessors, contents himself with the remark that "it can be shown that the ultimate result of collisions is that the kinetic energy becomes equally shared by each of the different degrees of freedom" which the molecule possesses. A plain straightforward proof of this theorem on simple general principles is greatly to be desired, but presumably does not exist, and proofs based on very elaborate mathematical reasoning are not of much service to engineers in general. Nothing is said, moreover, by the author as to the distribution of the velocities between the different molecules, and in this case a simple proof does exist, as Herschell's proof of the form of the probability function is certainly wholly valid in this particular case, even if certain pure mathematicians dispute its sufficiency when considered as a general proposition.

On page 359 of this appendix the author makes one very remarkable statement, which it would be well to have authoritatively confirmed or denied. He states that if the atoms constituting a triatomic molecule were arranged in a straight line, the arrangement would be an unstable one. Hence it would seem that the ordinary steam molecule should be represented by

$$\begin{matrix} H \\ | \\ O - H \end{matrix}$$

and not by $H - O - H$.

There seems no very obvious reason why the latter arrangement should be any more unstable than are the "open chains" met with in organic chemistry. Moreover, if due account be taken of the co-aggregated molecule in the case of water the linear arrangement seems to agree quite reasonably with the observed specific heat of steam. With no co-aggregation the linear arrangement of the atoms of H_2O would give a molecular specific heat at constant pressure of $\frac{7}{2}R = \frac{7 \times 1.985}{2}$ calories per 18 grammes of the substance: or $\frac{7}{36} \times 1 \cdot 985 =$ 0·386 thermal units per lb. Actually at 100 deg. C. about one-thirtieth of the weight of steam present consists of co-aggregated or double molecules, and if the state of co-aggregation did not change with the temperature the specific heat K_p would be increased by the presence of these double molecules to at least 0.395 thermal units per lb. Probably this is an under estimate as the constituents of a double molecule are somewhat slackly bound together and may thus have several additional degrees of freedom, raising the specific heat to perhaps as much as 0·420. The actual increase of specific heat due to co-aggregation is, however, much larger than the above figure would represent since the rise of temperature disaggregates some of these double molecules; the co-aggregation volume at 110 deg. C. being according to Callendar 0·3857, whilst at 100 deg. C. it is 0·4213. The weight which has been disaggregated in raising the temperature of steam at atmospheric pressure from 100 deg. to 110 deg. is therefore about 1/500 lb. The work required for this is presumably not a small fraction of the latent heat, so that to produce 1/500 lb. of new simple molecules will have required an energy expenditure of the order of perhaps three-quarters of a heat unit. Hence, we can on these lines account for a specific heat of 0·495, or more, and this figure is not far from the experimental value of 0·511. Some energy also, no doubt, exists in the "vibratory" form, but this would seem to be very small in the case of steam at 100 deg. C. Of this vibratory energy Sir J. A. Ewing gives a very useful description, the appendix containing the first account of Planck's quantum hypothesis written specially for the engineer. The author we note, takes $6 \cdot 55 \times 10^{-27}$ as the value of Planck's constant and 6.16×10^{23} as the number of molecules in 22·4 litres of gas at standard temperature and pressure. According to Millikan, whose results are generally considered as particularly reliable, these figures should be 6.620×10^{-27} and $6 \cdot 06 \times 10^{23}$ respectively.

The chapter on general thermodynamical relations will prove invaluable to the student. Here Sir J. A. Ewing has given the demonstration of some 50 equations connecting together thermodynamic properties of all kinds, and for convenience of reference has further grouped them together at the end of the chapter. All these equations represent conditions that must be fulfilled in the case of all fluids, however great their departure from the ideal state of a perfect gas. In the following chapter he discusses the application of some of these equations to particular fluids. This exemplification of the connection between the pure mathematics of the preceding chapter and the physical properties of fluids as we know them cannot be too highly commended. Van der Waals' famous equation receives adequate discussion here, and from the engineering standpoint still more important is the complete discussion of Callendar's characteristic equations for steam. These are now accepted as providing by far the most reliable basis for the discussion of the performance of steam actuated prime movers, and supersede the old tables based on Regnault's experiments or on the later experiments of Knoblauch and Jakob. The limitations of the equations in question are also clearly stated. They are not intended to apply up to the critical point, but for the ordinary range of temperatures and pressures usual in steam practice, they yield results mutually consistent, and in accord with the most reliable experimental results, and they have the advantage that the constants involved in them have a definite physical interpretation and are not merely empirical. In one important regard the physical basis of Callendar's equation is remarkably confirmed by Wilson's experiments on the expansion of super-saturated air where the nuclei of condensation appear to be the compound molecules of which the existence was assumed by Callendar in order to account for the fact that one lb. of steam invariably occupies a smaller volume than it would do were the ordinary gas equation satisfied.

In a second edition of the book we would suggest that the author should develop at greater length the kinetic theory. A chapter on the theory of radiation, would also be welcome, as radiation pyrometers are now proving of great value in many industries.

Labour Difficulties and Suggested Solutions. A Manual for Technical Students, Cashiers, Foremen, Departmental or Works Managers and Employers. By W. I. DEELEY, B.A., Honorary Demonstrator in Teaching at the Manchester University. Second edition, enlarged. London: Benn Brothers, Limited. [Price 10*s.* 6*d.* net.]

THIS book presents the result of much practical experience and of concentrated, well-directed thought upon a particular phase in the great problem of the reconstitution of labour, a problem that is exercising the minds and taxing the energy of all that have at heart the welfare of the community and of the Empire. Some there are, no doubt, who, consciously or unconsciously, propose remedies for the present turbulence and unrest that will serve their own interests, or even more selfishly, will tend to their self-aggrandisement; but with that class we have nothing to do here. The author hints occasionally at the action of disturbing elements, but his object is to urge the harmonious working of a well-organised machine, designed to minimise the jarring friction that cripples Capital, disorganises Labour, and diminishes efficiency in all its parts. His position of employment manager in a large Manchester firm equips him for the task he has undertaken, by giving him opportunity to see the raw material from which the skilled operative is formed and to watch, perhaps to guide, the training, that produces the thinkers and trusted leaders of great industrial movements. It is precisely this intimate contact with employers and employed that gives this book an especial value. The imprint of close study and personal experience is evident on every page, and there is little attempt to travel into more general considerations. Moreover, the book is the outcome of a series of lectures given at the Manchester School of Technology to third-year undergraduates, a scheme initiated and encouraged by a number of local firms in order to create a Department of Industrial Association, to enforce the importance of "Management" as a prominent factor in the conduct of relations between operatives and employer.

It is not necessary to inquire whether it is possible to inculcate the qualities of tact, adroitness, power of control and leadership by lectures and verbal instruction. It may be as Disraeli said that "he will rule who can rule," and character is the determining quality, but it is significant that those far-seeing men, engaged in the staple industries and bearing the heat and burden of the day, are of opinion that the disquiet permeating and revolutionising industrial administration will be rendered more harmless, "according as the attitude of employers, managers and workers is more enlightened, particularly in respect of the social service aspect of their functions." In the author's opinion, the labour difficulty, inherent in the industrial movement of reconstruction, is due to, or made more acute by, the want of competently-trained men who will guide the hewers of wood and drawers of water with a firm but sympathetic hand, maintaining discipline but upholding justice, neither bullying the rank and file, nor bullied by them. On the other hand, by the introduction of qualified assistants of trained intellect, the employers will have around them a set of trustworthy and capable men, from whom to select those who will aid in the conduct of business by diminishing friction and ensuring those good relations that make for increased output. It is an alluring and persuasive prospect, one to be encouraged by every means in the power of the well-intentioned, but it is to be feared that it is one that will never take permanent shape. There are two obvious objections, so obvious that the author does not discuss them, at least at any great length, which tell against the modern Utopia, as the author conceives it. One is that the introduction of a superior class, but little trained in the mechanical details of the works, would stop, or delay, promotion, and on that account such a measure would be resented by the energetic, progressive man who looks for recognition and advancement. The other is that the men would regard the new comers as a class apart, with whom they could not fraternise, and of whom they would be jealous, mistrustful, and suspicious. Of course, it may be urged that the very object of special training is to supply those qualities that would destroy mistrust and invite confidence, but it is an easy task to suggest suspicion against superiors, and it must also be remembered, that the novice would be heavily handicapped by the action of those who are ever at work to wreck all proposals that aim at producing greater efficiency and improving the relations between Capital and Labour. The fact that such a scheme would lead to content with the existing system is anathema to a class, whose hope is anarchy and whose creed is plunder.

It will be asked how is it that foremen and those filling responsible positions have not acquired skill in man management from actual practice, and what grounds there are for supposing that the deficiencies exhibited by this class are likely to be remedied by including this subject in the curriculum of technical colleges and making it a part of the general training of those who are ambitious to become foremen and managers. The answer to these questions is not forthcoming. The scheme has not advanced beyond the stage of suggestion; it has not been tried on any large scale. It may be doubted whether we possess the necessary machinery, and particularly a sufficient number of competent teachers to make the scheme a success. If it is necessary to await the training of the teachers, some more rapid method of removing old ills and introducing reforms will have to be sought out, though the author contends that no better scheme has been suggested. Unfortunately the salvation of British industry requires an immediate remedy. Time is of the essence of the problem. As Mr. Deeley states the case, "Reconstruction and a better understanding between man and management, rather than between Labour and Capital, cannot wait for a race of supermen."

In this book the lines are indicated for educating those who are to occupy the higher positions in the industrial edifice. The plan consists in suggest-

ing a series of such "cases" as are likely to occur in the control and direction of workmen, and to analyse the principles, or trade customs, by which they may be settled. Apparently the scheme is to prepare and store up such a large number of instances with the grounds for decision, that when a disputed point occurs in actual practice, the memory will suggest the proper method of relieving the situation or of meeting the difficulty. The author hopes that the method outlined in the treatise will be extended by the collection and discussion of typical cases furnished by foremen and managers from their actual experience. The full discussion of the principles involved—whether legal or expedient does not appear—will, it is thought, provide a text book for present and future guidance. The weak point in the plan is, that there is no compelling authoritative utterance, and only those comments will appear or be approved that appeal to the individual, who may be moved by sympathy or resentment, rather than by justice or precedent. The assertion of individual opinion and determination in the place of a loyal acceptance of the reasoned judgment of collective and constituted authority is wrecking the weight and influence of trade unionism, and one cannot doubt but that the spirit of hostility so often displayed, would prevent the utterance of any unanimous opinion and deprive the most careful deliberations of the force that should attach to them.

Just as all text books have a number of examples to test the pupils' proficiency and mastery of the subject, so a number of examples or test questions are submitted to exercise the ingenuity of the tyro. These questions differ from ordinary examples in so far as they do not admit of unique solutions. That does not make them the less interesting. They seem to have been composed as much with a view of making the pupil reveal his own character as to test his dialectical skill. In some cases, suggested solutions are supplied, in others, not, but all the conclusions will not be accepted, and if assent is given it may not be for the reasons assigned by the author. We should have liked to have seen the answer to the question, "What constitutes a 'good job'?" but the answer is withheld on account of an objection having been raised that the exercises are too elementary.

A word of praise should be given to much valuable advice, scattered through the book, intended to increase the capacity of foremen and of turning their responsible position to better account. Suggestions for the adoption of measures that would lead to their improvement are excellent, and the advice given on welfare work and related subjects is distinguished by wide knowledge and generous sympathy. The remarks on the Whitley scheme of Industrial Councils should be read by all, but it is to be feared too many have not taken the trouble to master this charter of democratic industrialism. When Mr. Deeley asks "Have the workers who pass their lives in an industry no opinion on the matter worth consideration?" we are afraid the answer must be different to that he confidently anticipates. We would, however, warmly second his plea for sympathetic and generous interpretation in what concerns man and management, and cordially endorse his view that "it is the duty of everyone to use this period of national trial to draw together all classes into such terms of better relationship as will increase the happiness of all and the welfare of all our industries."

NOTES ON NEW BOOKS.

The gradual return to normal conditions is shown by the re-appearance by degrees of the better-known annuals and year-books. Probably before the war this branch of the publishing world ran the risk of being rather overdone, and the weeding-out has not been altogether without benefit. The re-appearance of those books which have proved to be of undoubted service can be looked for with confidence, while others will not be greatly missed. With the motor trade in its present active condition it is not surprising to find the *Automobile Engineer Year Book for* 1920 (Iliffe & Sons, 6*s.* net) appearing for the first time since the war in somewhat enlarged form. The book is conspicuous for having no preface or apology for its appearance. From the title page one passes direct to tables and data relating specially to automobile work, which fill the bulk of the volume. A great deal of trouble must have been expended in collecting all the data given regarding British and foreign chassis. The work does not, of course, lend itself to review, but we commend it to the motoring world. It will doubtless soon regain the position it formerly occupied.

At the present time housing is the order of the day, and building operations are being actively carried out, in theory if not in practice. In point of fact, our present generation would seem to have solved the problem of building castles in the air; but notwithstanding this, few members of the community are in the position of the bricklayer of Crookham, in Hampshire, who is reported in the daily press to have built a five-roomed house—on *terra firma*—at a cost of less than 10*l.* This bricklayer needs no special guidance, but all other members of the community will welcome a guide book which quotes the cost of all materials which enter into house construction, house alteration and improvement. Such a publication is "*Laxton's Builders' Price Book for* 1920," which is said to contain about 73,000 prices. The present edition is the 103rd, and it is issued at the price of 4*s.* by Messrs. Kelly's Directories, Limited, 182 to 184, High Holborn, W.C. 1. It has a detailed index, and a list of specialities under their registered names, after which follow prices of all classes of materials, fittings and accessories. It is compiled for architects, builders, engineers and contractors, but appeals to a constantly widening circle of amateurs who are, of a necessity, gradually gaining experience in renovating their own homes.

The Marconi International Code Company, Marconi House, Strand, W.C. 2, have issued the "*Marconi Dictionary*," which has been specially arranged and edited for code users, by Mr. J. C. H. Macbeth, editor of the "Marconi International Code." The book will be found useful both as a dictionary and as a code, and for this latter purpose each word is numbered. Instructions in this latter connection are given, and a method of securing secrecy is suggested. The dictionary proper covers 35,728 words; there follow a glossary of automobile terms, one of aviation terms and one of wireless telegraphic and telephonic terms, the words in these three glossaries being also numbered, the total number being 38,928. The book closes with a long list of synonyms and antonyms to the number of over 12,000.

A desk manual in trade, commerce and navigation is the designation given to the "*Shipping World Year Book*," by its publishers, the *Shipping World* Offices, Effingham House, Arundel-street, Strand, W.C. 2, a title which is quite justified, seeing the character of the information it contains, its extent and completeness. Particulars are given concerning British, Colonial and foreign ports; situation, population, authorities, trade, tides, prevailing winds, accommodation, in each case, the ports being arranged alphabetically, these data covering about half the book, the remaining half being taken up by the tariffs of all nations. There are also a number of tables of conversion, of formulas, &c., information on freeboard, load-lines, a digest of merchant shipping and other acts. The book for the current year has 2,066 pages; it can be obtained at the price of 15*s.* net, post free, from the above offices. It is accompanied by an excellent map of the world specially prepared by Mr. J. G. Bartholomew, P.R.G.J., &c.

A publication which appeals to a very large circle of readers is "*The South and East African Year Book and Guide*," which gives a vast amount of detailed information on the Union of South Africa, Rhodesia, Belgian Congo, Portuguese Africa and the former German colonies. The information covers practically every subject and is illustrated by a large number of detailed maps and plans. The book contains about 800 pages of text, carefully indexed. The publishers state that the sections dealing with South-West Africa (formed by German S.W.A.), Portuguese Angolaland and Katanga (Belgian Congo) have been rewritten and enlarged, attention being directed to the extraordinary development by means of which the copper mines of Katanga are opening up a portion of the Continent hitherto almost unknown. Also that the requirements of young men who have recently been fighting, and who may be desirous of settling in the colonies, have been carefully borne in mind. The present edition is the twenty-sixth; the editors are Messrs. A. S. Brown, F.R.M.S., and G. G. Brown, F.R.G.S.; and the book is issued at the price of 2*s.* 6*d.* by Messrs. Sampson Low, Marston and Co.

Italy has long since made a name for herself in regard to architecture, engineering and the carrying out of public works of the most intricate nature. We may add in this connection that, so far as we are aware, an Italian architect has first to graduate as an engineer. Italy has, also, always been in the front rank in the matter of naval construction, and a further proof of her enterprise in this special branch is afforded by the Proceedings Volume XIV, year XXIII (1919) of her Institute of Naval Architects, the president of which is the Hon. Salvatore Orlando. The work is entitled "*Atti del Collegio degli Ingegneri Navali e Meccanici in Italia*," and contains, among others, papers with the discussion thereon dealing with the work of the Italian Navy during the years 1915 to 1918, dealing also with internal combustion engines for marine purposes, seaplanes and aeroplanes, the evolution of submarine boats, &c. An interesting paper, which affords evidence of the resourcefulness, energy and skill of Italian naval architects, is the one which deals with the salvage of the battleship Leonardo da Vinci, which sank off Taranto in August, 1916, by reason of an explosion which occurred in the aft ammunition hold. The various alternatives gone into for raising her and the means finally adopted are reviewed and illustrated in detail. The book is an account of the meetings of the Institute held last October.

The subject of piles and pile-driving is dealt with extensively in a book measuring 10 in. by 6¼ in., of 350 pages, entitled "*Pieux et Sonnettes*," by Messrs. E. Noë and L. Troch, C.E., and published at the price of 20 francs by Messrs. Gauthier-Villars and Co., 55, Quai des Grands-Augustins, Paris. The book opens with information as to wood piles, followed by data concerning metallic and reinforced concrete piles of all the different types, and sheet piling. Theoretical considerations in regard to pile-driving form the subject of a separate chapter in which a number of formulæ are given with reference to shock and pile-driving work. The various machines used in pile-driving are illustrated and described, also pile and sheet-piling extractors. Special chapters cover the setting of piles by means of a water jet and considerations as to the equilibrium of piles. Static and dynamic tests are also reviewed, and the advantages of steam driving machines entered into. The book will be found a most useful guide by all engineers in charge of constructional work of every description.

BOOKS RECEIVED.

United States Geological Survey. Nos. I: 5. *Silver, Copper, Lead and Zinc in the Central States in* 1918. *Mines Report.* By J. P. DUNLOP and B. S. BUTLER. I: 6. *Gold, Silver, Copper and Lead in Alaska in* 1918. *Mines Report.* By G. C. MARTIN. I: 7. *Quicksilver in* 1918. By F. L. RANSOME. I: 8. *Gold, Silver, Copper and Lead in South Dakota and Wyoming in* 1918. *Mines Report.* By CHARLES W. HENDERSON. I: 9. *Arsenic, Bismuth, Selenium and Tellurium in* 1918. By JAMES M. HILL. I: 23. *Manganese and Manganiferous Ores in* 1917. By D. F. HEWETT. I: 24. *Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in* 1917. *Mines Report.* By CHARLES W. HENDERSON. II: 12. *Gypsum in* 1918. By RALPH W. STONE. II: 13. *Sand and Gravel in* 1918. By R. W. STONE. II: 15. *Peat in* 1918. By C. C. OSBON. II: 35. *Coal in* 1917. Part B. *Distribution and Consumption.* By C. E. LESHER. Bulletin Nos. 698. *Bibliography of North American Geology for* 1918, *with Subject Index.* By JOHN M. NICKELS. [Price 10 cents.] No. 711. C. *Peat in the Dismal Swamp, Virginia and North Carolina.* By C. C. OSBON. Water Supply Papers No. 436. *Surface Water Supply of the United States,* 1916. Part VI. *Missouri River Basin.* No. 440. Part X. *The Great Basin.* [Price 25 cents.] Nos. 442 and 443. Part XII. *North Pacific Drainage Basins.* (A) *Pacific Basins in Washington and Upper Columbia River Basin.* [Price 15 cents.] (B) *Snake River Basin.* [Price 15 cents.] No. 450. *Geology and Water Resources of the Gila and San Carlos Valleys in the San Carlos Indian Reservation, Arizona.* By A. T. SCHWENNESEN. Washington: Government Printing Office.

Pieux et Sonnettes. Par EDOUARD NOE et LOUIS TROCH. Paris: Gauthier-Villars et Cie. [Price 20 francs.]

The Port of Sydney, New South Wales. Official Handbook. Sydney: The Sydney Harbour Trust Commissioners.

German and English Commercial Correspondence. By N. SADERY and WILLIAM CHEVOR-MAURICE, A.I.L. London: E. Marlborough and Co. [Price 1*s.* 9*d.* net.]

The Union Castle and the War, 1914–1919. By E. F. KNIGHT. London: Union Castle Steamship Company, Limited.

The Automobile Year Book for 1920. London: Iliffe and Sons, Limited. [Price 6*s.* net.]

Cotton Spinning. By WILLIAM SCOTT TAGGART, M.I.Mech.E. Vol. III. Fifth edition. London: Macmillan and Co., Limited. [Price 10*s.* net.]

Marconi Dictionary. Specially arranged and Edited for Code Users. By J. C. H. MACBETH. London: Marconi International Code Company.

Steamship Coefficients, Speeds and Powers. By CHARLES F. A. PYPE. Second edition. London: E. and F. N. Spon, Limited. [Price 25*s.* net.]

The Year Book of Wireless Telegraphy and Telephony, 1920. London: The Wireless Press, Limited. [Price 10*s.* 6*d.*]

THE LATE MR. WILLIAM SHELDON.

We greatly regret to have to announce the death of Mr. William Sheldon, which occurred on the 20th ult., at Ashdene, Roundhay. Mr. Sheldon, who was in his sixty-ninth year, had been in failing health for some time, but he continued to the last to evince an undiminished interest in the business of Messrs. Fowler's Steam Plough Works with which he had been so long connected. The deceased was born at Hanchurch, Newcastle-under-Lyme, and served his time at the Stoke works, afterwards working, for a time, at Messrs. Lairds' Shipbuilding Yard at Birkenhead. His connection with Messrs. Fowler dates from 1879, at which time Mr. Sheldon was engaged as foreman over their tool shop. The qualities he displayed in this capacity, however, inspired all grades of his fellow workers with such confidence that in 1888 he was appointed assistant works manager. Nine years later, in 1897, large trade developments and works extensions were undertaken by the firm and Mr. Sheldon was then appointed works manager. Under the chairmanship of the late Mr. R. H. Fowler, the growth of the concern and the increase in the volume of its business was such that Mr. Sheldon was given a seat on the directorate in 1906, a position which he retained until January of last year, when he was obliged, by ill-health, to relinquish his business activities. As a practical engineer and a capable works organiser, Mr. Sheldon had few equals, and his personal character was such as to endear him to a wide circle of friends among agricultural engineers, as well as to those with whom he was more closely associated in the Leeds Steam Plough Works and its overseas branches.

Mr. Sheldon usually represented Messrs. Fowler at the district meetings of the Engineering Employers' Federation, by which body his carefully considered opinions and impartial judgments were highly respected. He also took an active part in the work of the Leeds Association of Engineers, which he joined in 1886, serving for many years as a member of the committee and occupying the presidential chair for the session 1898–99; he was one of the trustees of the Association up to the time of his death. Similar associations in different parts of the country had his warmest support, and he always acted as one of the official delegates at inter-association gatherings. Members of kindred associations visiting Leeds during the past thirty years will have pleasant recollections of the part played by Mr. Sheldon in making these visits profitable and interesting. He rendered constant assistance in Church and philanthropic work, but he disliked publicity, and although he took no active part in politics was a Conservative with the broadest outlook.

The funeral took place at St. John's Church, Roundhay, on the 24th ult., and was attended by numerous members of the firm of Messrs. John Fowler, as well as representatives of the Leeds Association of Engineers, and others connected with the engineering industry of the Leeds district.

THE LATE MR. CHARLES E. RHODES.

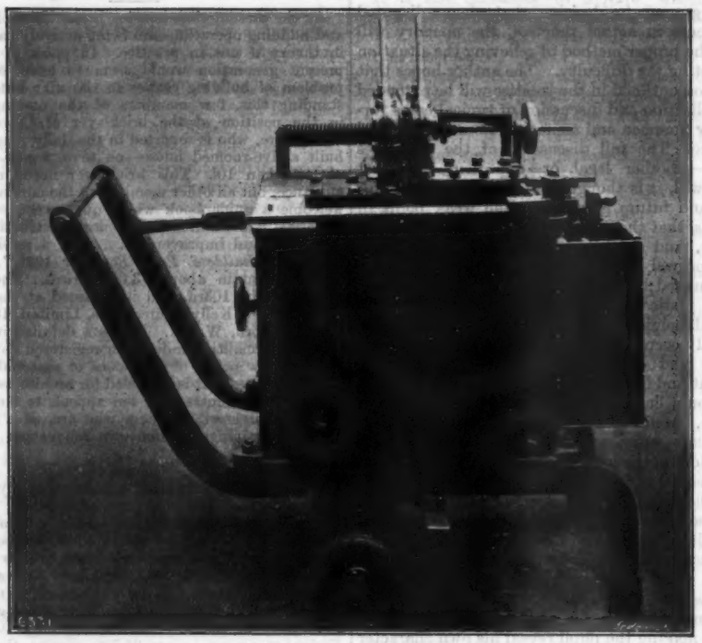
We regret to have to record the death, which occurred on the 7th inst., at Whixley, near York, of Mr. Charles Edward Rhodes, of Lane End House, Rotherham, who was for many years most actively engaged in colliery developments.

Mr. Rhodes was born at Pinder Oaks, Barnsley, in May, 1849. His father was for about half a century in the Fitzwilliam Estate Office, Wentworth, and, in partnership with Messrs. Hague and Harvey, owner of the Cowhouse Colliery, which was sunk in about the year 1855, and was the first of a series of collieries to become the property of Messrs. John Brown and Co., Limited, Sheffield. Mr. C. E. Rhodes was educated at Lindow Grove, Cheshire, and at the Lancaster Royal Grammar School. He served a pupilage of three years (from 1866 to 1869) to Mr. Charles Bartholomew, at the Wombwell Main Colliery, and was later, and during four years (from 1869 to 1872), an assistant in the offices of Messrs. J. and P. Higson, Manchester, where he was engaged in different kinds of mining work for Messrs. Logan and Hemingway, contractors, at Grimsby, Rotherham and other places. Since December, 1873, he held the position of engineering manager for Messrs. John Brown and Co., Limited, for whom he sank several shafts and developed a number of pits, having acted throughout as engineer and superintendent of the whole of the work.

Mr. Rhodes from the very commencement of his activities worked unremittingly for the increase of safety in mining, and his services proved of great value to Royal Commissions appointed to deal with this subject. He carried out also numerous tests personally in connection with different types of lamps and explosives, and also in mining methods and appliances generally. His abilities as a mining engineer were greatly in request outside his actual sphere of activity. In the course of his life, he was consulted and he advised in regard to a large amount of important mining work of all kinds. Mr. Rhodes was chairman of the Rawmarsh Local Board in 1887; president of the Midland Institute of Mining, Civil and Mechanical Engineers, from 1889 to 1890; he became a member of the Institution of Civil Engineers in 1890; in 1900 he was president of the National Association of Colliery Managers; president of the Institution of Mining Engineers in 1907; and in 1912 he was appointed a member of the committee to inquire into the circumstances in which spontaneous combustion of coal occurs in mines, its causes, and the means of preventing it or of dealing with it when it has arisen. He became a Fellow of the Surveyors' Institution in 1914; in 1915 a member of the Coal Mining Organisation Committee; in 1916 a member of the Standing Committee on Mining in connection with the Government scheme for scientific and industrial research. In the same year he was appointed a member of the Coal Conservation Committee of the Ministry of Reconstruction; in 1917 a member of the Advisory Board to assist the Controller of Coal Mines; and in 1918 a member of the Land Requisition Committee of the Ministry of Acconstruction. Mr. Rhodes was also chairman and director of a number of mining and industrial concerns.

ELECTRIC WELDING MACHINE FOR STEEL TAPE.

CONSTRUCTED BY THE WESTMINSTER ENGINEERING CO., LTD., ENGINEERS, WILLESDEN.



WELDING MACHINE FOR STEEL TAPE.

An interesting and unusual type of electric welding machine is illustrated in the figure above. It is constructed to weld steel strip and is mainly intended for joining the various lengths of steel tape which are used in the armouring of cables. The welding of such tape has obvious advantages over brazing in the matter of time occupied, while the possible alternative method of making the joint by means of rivets would obviously also take longer and would result in a thick joint which is objectionable as interfering with the jute covering and the final diameter of the cable. The machine has been constructed by Messrs. The Westminster Engineering Company, Limited, of Victoria-road, Willesden Junction, to the instructions of Messrs. The Electric Welding Company, of 28, Basinghall-street, E.C. 2. The tape which is dealt with by the machine is of such proportions as 1½-in. wide by 0.03 in. thick and is difficult material to weld. It has proved impossible to deal with it satisfactorily by any method of slow welding and the flash method is employed in the machine with which we are concerned. The procedure employed results in the upset being burnt and brittle so that it is easily removed. We should perhaps say here, in order to be clear in our description, that the two sections of tape are butt welded directly end on. There is no lap, and when the upset has been dressed off the joint has the same cross sectional dimensions as the original tape.

The machine consists of a transformer in a case which carries the welding mechanism on its upper side. There are two horizontal jaws which hold the two pieces of tape being dealt with. One is fixed and the other is movable. In large machines of the type the lower blocks of the jaws are water-cooled, but this has not proved necessary in the size of machine illustrated. The lower blocks of the jaws are of copper, and the steel tape is gripped between them and hinged steel tongues operated by cams and levers. The steel tape is sheared off square and the lower face is cleaned to ensure a good contact before it is placed in position in the jaws. It is clamped with a gap which is determined by a special gauge; in general the wider the tape the greater the gap necessary to get a sound weld. When the tapes to be joined are clamped in position the circuit is closed and the horizontal hand lever which can be seen in the foreground in the figure is swung over. This releases a spring operated toggle mechanism which slides the loose jaw. After a predetermined movement this jaw trips an automatic switch and opens the circuit. The trip gear has an index and scale which give the exact amount of upset. It can be set to suit the requirements of the material being welded. The spring operated toggle is so arranged that the pressure between the two steel tapes is at a maximum on the completion of the weld. The spring tension, however, is set so that overlapping is not caused during welding. When contact is made the weld emits a shower of sparks as the metal is burnt away until the whole width of the ends of the tapes is in a plastic state. The spring pressure closing up the moving jaw opens the automatic switch before the end of the jaw travel, so that the jaw continues to advance until all the burnt metal is squeezed out of the joint.

The relationship between the initial gap, the pressure and the upset is of importance in securing a satisfactory job and the gauge from which the correct gap is determined also allows of the correct setting of the tension and point of cut-off. In connection with the output of the machine, it may be said that a strip 1½-in. wide, by 0·03 in. thick of mild steel is welded practically instantaneously with an input of 12 k.v.a. A strip of similar material, 2½ in. wide by 0.06 in. thick, is welded in 2½ seconds with an input of 20 k.v.a. The weld is a perfect one and not at all brittle. In samples we have seen in which the upset had been dressed off, the welded strip could be bent about like a piece of the unwelded material with no sign of fracture. The upset of burnt metal is comparatively soft and may be flattened with a hammer. We understand that for many classes of cable armouring this is all that is necessary. The upset, may, of course, be chipped or ground off if desired, and when this is done the welded strip is practically indistinguishable from an unwelded sample. The alignment obtained between the two tapes which are joined is remarkably good.

THE CASTING OF GAS RETORTS.*

By Dr. J. W. MELLOR and W. EMERY.

THE experiments were made to ascertain the necessary conditions for successfully casting refractory ware containing a high percentage of grogs.

The casting slip can be prepared from any fireclay and grog, but in the experiments the materials used were Stourbridge clay and Stourbridge grog, the latter being mixed ungraded, as used in the trade, dust (passing 16's sieve), fine (staying on 16's, passing 8's), medium (staying on 8's, passing 4's), or coarse (staying on 4's, passing ¼ in.). Sodium carbonate or silicate—usually both—is added to make the slip fluid without allowing the grog to settle, the amount being determined by trial and depending on the nature of the clay, the size of the grog, and the proportion of clay to grog. Some clays work best with equal parts of silicate (of specific gravity 1·3) and commercial soda ash, whilst with others a larger proportion of silicate answers better. The mixture of water glass (silicate) and soda ash is called the alkali mixture. The average amount of alkali mixture required is only 0·3 per cent. calculated on the dry weight of the clay used, and it has virtually no influence on the refractoriness of the clay under ordinary conditions. Some of even this small amount leaves the clay and passes to the plaster mould.

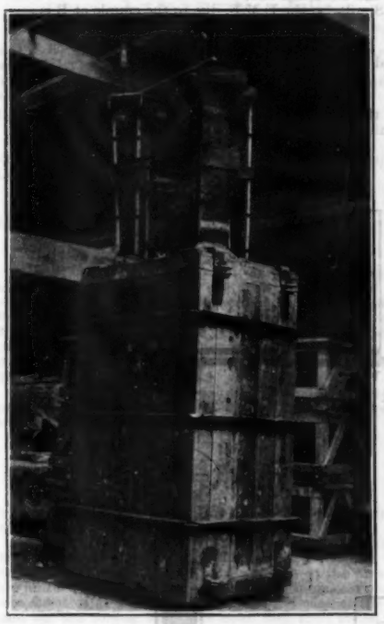


FIG. 1. MOULD READY FOR FILLING.

FIG. 2. RETORTS AS CAST.

* Abstract of a paper submitted to the Ceramic Society at their meeting at Stoke-on-Trent, on November 10 last, and also read before the Institution of Gas Engineers, on Tuesday, the 1st inst.

Several methods of plunging in ordinary use were tried without any notable difference in the quality of the slip produced—as (1) adding the mixed clay and grog in a continuous stream to the water and alkali already in the blunger, (2) blunging the clay with water and then adding the grog and alkali, (3) blunging the clay with water and sodium silicate and then adding the soda ash. With an efficient blunger, a uniform fluid slip is obtained in 2 hours to 3 hours, the specific gravity being nearly 1·9, corresponding with 38 oz. per pint. The fluid slip has about 21 per cent. of water, whilst the average plastic clay for moulding, &c., has about 25 per cent. of water. The readings of the ammeter connected with the drive of the blunger give valuable information as to the condition of the materials in the blunger.

Solid cylinders, 20 in. high, were made from mixtures of 100 parts clay with 43, 46, 55, 100, 120, 150, 175 parts mixed grog, and with 175 coarse grog, respectively; after drying, and cutting the cylinders vertically, the sections of the castings appeared uniform throughout, so that the suspended grog showed no tendency to sink in the slip.

Other castings were made in small saggar moulds with straight central cores, using a mixture of equal parts of clay and grog. Certain practical difficulties arise with cored moulds, viz.: If the core be drawn too soon, the casting collapses; if the core be left in too long, the casting adheres to it and fractures when the core is withdrawn; if provision be not made for the escape of air during the filling, air pockets may be formed; if a sufficient head of slip be not maintained during the casting, the inside of the cast piece is inferior in texture to that portion immediately in contact with the mould. Three castings were made and left in the mould for 24 hours, 16 hours and 19 hours respectively, the core being difficult to withdraw in the first case, but easily detached in the other two. After withdrawal, the saggar was found to be fractured in the first case, too soft after 16 hours, and good after 19 hours. The best length of time in the mould depends upon the condition of the mould and slip, temperature of casting, &c. Sections of these saggars disclosed cavities, a defect which was eliminated by casting under a higher pressure (obtained by attaching long funnels to the head of the mould); a number of saggars cast in this way exhibited a perfectly uniform texture.

Shrinkage.—The diameter of the mould was 10 in., and the cast saggar immediately after drawing the core was 9¼ in., the shrinkage being then 1·25 per cent. After drying white hard, the diameter was 9⅛ in. (additional shrinkage 1·26 per cent.) and after firing at cone 7 it was 9⅛ (additional shrinkage, 2 per cent.), giving a total shrinkage from mould to finished piece of 4·375 per cent. The sides of the saggar were 1 in. thick.

Surface Cracking.—The saggars, on drying, developed surface cracks, giving them a crazed appearance. This is due to a separation in the mould of an extremely thin superficial layer of fireclay, which on subsequent drying contracts more than the grogged interior. The cracks do not extend inwards on firing, and the finished saggars were quite sound. They were made of mixtures containing 100 parts of clay with 25, 50 or 200 parts of grog, and the latter being used in three grades—fine, medium and coarse—gave nine mixtures in all.

With regard to the effect of composition on surface cracking, all clay gave a product free from cracks, whilst with equal parts of clay and grog, the effect depended on the grading of the grog; equal proportions of fine, medium and coarse grog produced fine cracks; coarse grog was worse, and fine grog better, than the preceding; in the case where mixed grog was used the surface was smoothed over while green with a spatula, and the finished piece showed only very fine surface cracks.

For casting larger pieces, a special mould was constructed to produce a ⊂ section retort, 2 ft. 4 in. by 2 ft. by 5 ft. long, and having a thickness of 3 in. throughout—all after being fired.

What is believed to be the first retort produced in England by the casting process was exhibited at the annual meeting of the Institution of Gas Engineers in London, in May, 1919. It showed extensive surface cracking owing to the high proportion of grog used, but the texture was uniform all through. In subsequent castings the surface was improved.

The texture of the retorts was tested by comparing the porosities and after-contractions near opposite ends of a cast retort, and a retort made by hand in the ordinary way. The contractions of the cast retort are somewhat higher than the standard, but the firing temperature was rather lower, and this can easily be rectified. The important point is the negligibly small difference in texture at the opposite ends of the cast retort. The hand-made retort used for the test was made before the specification was established. The porosities at top, middle and bottom, were 27·5, 27·5 and 28·3 respectively for the cast retort, and 26·2, 26·6 and 27·2 for the hand-made retort. The contraction of the cast retort was 1·75 for top and 1·72 for bottom.

In a proposed installation, the mixture of clay and grog passes from the conveyor to the elevator, and thence to the blunger; the water and alkali mixture passes from a tank to the blunger. The blunged mixture passes to the agitator, whence it is delivered direct to the mould.

It is difficult to compare costs of manufacture. The plaster of Paris moulds are estimated to make at least 60 casts. Each original mould (inclusive of modelling) cost about 50*l.*, and replacing the plaster for another 60 casts about 15*l.* Instead of renewing all the plaster it might prove more economical to renew it to a depth of about ½ in. from the face, as in Bruce Bailey's patent (British Patent No. 104,448, July 7, 1916).

If the casting process answers anticipations, it would probably be advisable to have retorts made in standard shapes and sizes, so as to reduce the cost of storing moulds, &c. The time occupied in casting a retort is about 15 minutes, the core is removed in about 24 hours, and the retort is removed from the mould 24 hours later. It would be just as easy to cast a mouthpiece (with or without holes) on a retort or a sectional retort, as to cast one without. Drying requires less time than usual, because there are no joints to be provided for. An intelligent youth could be taught all that is needed, in a very short time, for making retorts by this process, but skilled supervision is required in managing slip and moulds.

A denser retort with less tendency to crack can probably be made by the casting process than in other ways, because the great homogeneity of the retort lessens the tendency to set up local strains, which must be a prime cause of the cracking.

The committee were so much impressed by the promising results of the first attempts at casting large pieces, that they arranged for a personal inspection of the operations at the Berry Hill Fireclay Works, Stoke-on-Trent, where they saw the filling of the mould and the withdrawal of the core (in three longitudinal sections). The mould was filled in about 10 minutes, and required about 11 cwt. or 12 cwt. of the slip to fill it.

One fired retort was found to weigh 8½ cwt., and another was broken in pieces, and was found to be solid and of practically uniform structure throughout, apart, of course, from the comparatively smooth, finegrained, but hard, surface skin.

The whole period from the time of casting to the time of drawing the finished retort from the kiln was three weeks, about two weeks of which was taken up by the slow drying. The retort was in the kiln six days, and half of that time was taken up in the cooling.

THERMO-ELECTROMOTIVE FORCE AND ALLOY RESEARCH.

*The Study of Thermal Electromotive Force as an Aid to the Investigation of the Constitution of Alloy Systems, with an Appendix on the Peltier and other "Effects."**

By JOHN L. HAUGHTON, M.Sc. (of the National Physical Laboratory).

IN the investigation of the constitution of a series of alloys, there are two methods of attack which stand out pre-eminently above all others. The first of these is the measurement of heat absorptions or evolutions as the alloy is heated or cooled through the various critical points. This method has been developed to a very high pitch of perfection, and while it is generally employed in a qualitative manner only, quantitative results are sometimes obtainable, though the exercise of very great care and restraint is necessary in such cases. Many of the simpler types of constitutional diagram can be established, at least approximately, by thermal analysis† alone, though it is not possible accurately to determine limits of solubility, or indeed any line that departs markedly from the horizontal, by this method. Results of a high order of accuracy are probably obtainable from thermal curves in a shorter time than is possible by any other method.

In spite of these advantages, the method suffers from one drawback. There is a minimum speed at which curves can be taken if small heat evolutions are to be detected, and this speed may not be—indeed in the majority of cases probably is not—sufficiently slow to enable the alloy to attain equilibrium. Hence—to quote an example of frequent occurrence—eutectic arrests may be found on the thermal curves of alloys which contain no eutectic when in equilibrium. This disadvantage can, to a certain extent, be overcome by cooling the alloys with extreme slowness, so as to ensure that all the equilibrium conditions are attained at the lowest temperatures, and then taking a heating curve of the slowly-cooled alloy. Since reactions generally take place much more readily on rising than on falling temperatures, it is probable that a nearer approach to equilibrium will be obtained in this way than when a cooling curve is taken. The method, however, may be very lengthy, and it is by no means certain to give true equilibrium results.

The second of what may be called the fundamental methods for the investigation of alloy systems is the microscopic examination of annealed, or slowly cooled and quenched specimens. This method suffers from none of the disadvantages which are inherent in thermal analysis, because it is possible to ensure that all the specimens examined are in equilibrium. Indeed, it may be said that there are no theoretical objections to this method of investigation. There are, however, a few practical limitations which sometimes arise. In the first place, quenchings much above the solidus are unsatisfactory, owing to the granulating effect of pouring moulten, or semi-molten, metal into water. Secondly, there is sometimes difficulty in obtaining a suitable etching reagent which will differentiate between two constituents with certainty. It may also be impossible to quench the material with sufficient rapidity to prevent the occurrence, to a greater or less extent, of a transformation which normally takes place at a temperature lower than that of quenching. A well-known example

* Paper read before the Institute of Metals, March 12, 1920.

† The term "thermal analysis" is restricted by some writers to the quantitative measurement of the heat evolved on an arrest, and by means of this the investigation of the point of maximum energy of the reaction, and, by exterpolation, the determination of its limits. In this paper, however, the term is applied generally to the study of alloy systems by means of thermal curves, whether quantitative or not.

of this is to be found in the impossibility of preserving austenite in carbon steels by quenching.

In spite of these drawbacks these two methods are, and probably will always remain, by far the most important in the investigation of an alloy system. It is often possible, however, to obtain a considerable amount of evidence on the constitution of alloys from the investigation of their physical and mechanical properties, though these methods must always be regarded as subsidiary to the two principal ones mentioned above. The physical properties which are generally investigated are density, electrical and thermal conductivity, thermo-electric power, magnetic and thermo-magnetic properties, electrolytic potential, heat of formation, photo-electric properties, and optical properties. Many of these methods have the great advantage that they can be carried out with extreme slowness, and therefore equilibrium conditions may be maintained throughout the whole experiment. It is not proposed, however, to consider in this paper the relative advantages and disadvantages of these various methods, but to discuss in some detail one of them, viz., the study of thermal electromotive force.

If two different metals are connected together in such a way as to form a continuous loop or circuit, and one of the junctions is maintained at a different temperature from the other, an electromotive force will be developed which will cause a current to flow round the circuit. The value of this E.M.F. will depend on the temperature difference between the hot and the cold "junction," and on the materials forming the "couple"; and in this connection it should be noted that two different polymorphic modifications of an alloy can be regarded as two different materials, as can two samples of the same alloy, the one existing above, and the other below, a line separating two phase fields. If a wire of some metal, such as platinum, which is known to have no allotropic transformations, is connected so as to form a loop with a wire of the metal under investigation, some apparatus for measuring E.M.F. being included in the circuit, and one of the junctions is heated while the other is kept at a constant temperature, it will be possible to detect changes in the alloy under investigation by the occurrence of breaks in the temperature E.M.F. curve. In this connection it may be noted that it is to be expected that the appearance of a new phase would be indicated by a change in the slope of the curve, while in the case of an allotropic modification the temperature at which the transformation takes place would be indicated by a steep step in the curve.

There is another way in which this property can be used in investigating an alloy system. A series of wires of the different alloys can be made up and their E.M.F. obtained against a standard metal, one junction being kept at zero and the other at a definite temperature —say, 100 deg. C. The results are plotted on an E.M.F.-composition curve; or better, the thermo-electric power $\left(\text{the ratio } \frac{d\,E}{d\,T}\right)$ is plotted against composition. The forms of these curves will be discussed later. In the great majority of the work that has been done on this subject the second of these methods has been employed, and the equilibria of several systems in the neighbourhood of ordinary room temperatures have been investigated in this manner.

The curves given, when the thermo-electric forces of a series of alloys are plotted against the composition, are very often complex. Broniewski* has made a thorough analysis of a number of curves, and the following abstract of his conclusions may be of interest.

Any binary alloy system containing compounds can be divided up into a number of other systems, each compound being regarded as a new component. In any one of these secondary systems there can only exist solid solutions and mechanical mixtures. The components may be mutually soluble in each other; or one, or both, may be partially soluble, an eutectic mixture being formed between them; or, finally, the components may be insoluble in each other† and give rise to a simple eutectiferous series.

When the two components are insoluble in each other, the thermal E.M.F.-composition curve is nearly a straight line between their thermal E.M.F.'s, if the composition by volume is used, and not the weight or atomic composition. (In many instances given by Broniewski the line departs appreciably from straightness. This may be due to the fact that he has calculated the volume from the specific weights of the components, and does not appear to have made any allowance for the change in volume which may easily take place on alloying.‡)

When one component dissolves in the other it either raises or lowers the thermal E.M.F. of the component, the effect of the first addition being much greater than that of later amounts.

The three types of curves are shown in Fig. 1, where α is due to a mechanical mixture (eutectic series); and β and γ to solid solutions.

The curve of thermal E.M.F. of an alloy system between two components (a compound being considered as a component) is built up of elements or branches similar to those shown in Fig. 1, and no system can contain more than three branches; so that the occurrence of more than three branches on the thermal E.M.F. curve of any system indicates the existence of a compound.

Broniewski indicates 13 forms which can be built up of the elements of Fig. 1, taken one, two or three at a time, six of them being principal forms, and seven derived from them by reversing the order. The chief of these are: (*a*) For mixtures: a straight line. (*b*) For continuous solid solutions: a ∪-shaped curve, upright or inverted; or two other forms which have not been found in practice. (*c*) For the case where one component is soluble in the other, the solvent forming a eutectic series with the soluble component: a curve and a straight line. (Four subdivisions are referred to.) (*d*) For a eutectic series bounded by solid solutions at both ends: two curves joined by a straight line.

Many of the subdivisions are made by simply reversing the order in which the curve is plotted, and seem hardly worth distinguishing from each other. When a compound occurs it is indicated: (*a*) By a break in the curve, if the compound forms one phase of a simple eutectic series. (*b*) By a maximum or minimum when the compound forms solid solutions with both the adjacent phases, except in the case where: (*c*) one of the solid solutions has a curve of the shape shown in Fig. 1*a*, the other giving rise to a curve similar to Fig. 1*β*, in which case the curve passes smoothly through the composition of the compound.

Owing to the fact that, in the case of solid solutions, the shape of the composition-E.M.F. curve is stated to change with change of temperature, a solid solution may show a curve of the shape of Fig. 1*a* at one temperature, and of Fig. 1*β* at another. Between the two it will be a straight line, and therefore the absence of a curve of type *a* or *β* at one temperature is no proof of the absence of a solid solution, though its presence is conclusive evidence for the existence of the solid solution.

Referring to the shape of the curve in a eutectiferous series, Broniewski, in the paper quoted above, says that the rectilinear relationship is to be expected, because "in this case a large number of local couples should be formed in which the circulating currents caused by the difference in the E.M.F.'s of the two components would lower the thermal E.M.F. of the stronger constituent, the more so as the proportion of the weaker constituent increases and, consequently, its resistance becomes less" ("d'autant plus que la proportion du constituent le plus faible augmente et que, par consequent, sa resistance diminue").

This last passage is very obscure. The equiaxial growth of a sphere, cube or similar body, would certainly lower its resistance; for in the case of a cube, for example, the effect of an increment on all six faces would be an increase in the resistance due to the increments on the two faces at right angles to the direction of flow of the current, but a reduction in the resistance due to the other four increments, and this latter would be approximately double the increase of resistance. It is not easy, however, to see what bearing this has on the E.M.F.'s generated by the local couples. In addition to this, it occurred to the author that the arrangement of the constituents might affect the E.M.F. This may be investigated by considering two extreme cases. Suppose in the first place, that the two constituents are arranged in alternate layers stretching right across the bar, as shown in Fig. 2, and suppose that the constituent represented by unshaded strips is electro-positive to the standard metal and to the shaded constituent. To simplify matters still further, let us consider that each of the layers is of the same thickness and that the fall of temperature over each strip is δT, T being the temperature of the hot end, the cold junction being at zero. Then, assuming that no transformations occur in the material under investigation, the E.M.F. at T is:

$$E = b\,T + c\,T^2,$$

where b and c are constants depending on the metals of the junction. (This is known as the law of Avenarius.*)

Consider next the junction A, which will be at the temperature $T - \delta T$. The E.M.F. due to this will be:

$$E_A = -\{b'(T - \delta T) + c'(T - \delta T)^2\},$$

the negative sign being due to the fact that the E.M.F. will be opposed to that of the couple first discussed, as the shaded constituent has been assumed to be negative to the unshaded one.

Similarly, the E.M.F. due to the couple at B is:

$$E_B = b'(T - 2\,\delta T) + c'(T - 2\,\delta T)^2,$$

and that due to the couple at C is:

$$E_C = -\{b'(T - 3\,\delta T) + c'(T - 3\,\delta T)^2\}.$$

If there are n sections we shall have a total E.M.F. which we can call E_t, of:

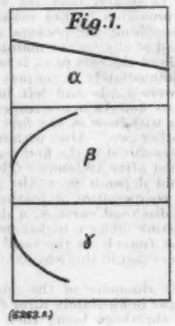


Fig.1.

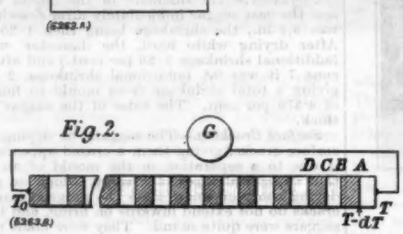


Fig.2.

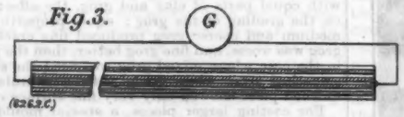


Fig.3.

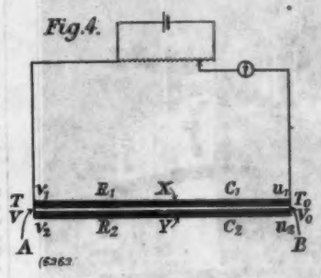


Fig.4.

Fig.5.

$$\begin{aligned} E_t &= b\,T + c\,T^2 - \{b'(T - \delta T) + c'(T - \delta T)^2\} \ldots \\ &+ b'(T - 2\,\delta T) + c'(T - 2\,\delta T)^2 - \{b'(T - n\,\delta T) \ldots \\ &+ c'(T - n\,\delta T)^2\} \\ &= b\,T + c\,T^2 + n\,\delta T\left(\frac{c'\,\delta T\,n}{2} - c'T - \frac{b'}{2}\right) \end{aligned}$$

when n is an even number. But

$$n\,\delta T = T$$

$$\therefore \quad E_t = b\,T + c\,T^2 + T\,c'\,T/2 - c'\,T^2 - b'\,T/2$$

$$= T(b + c\,T + c'\,T/2 - c'\,T - b'/2)$$

$$= T(b + c\,T - c'\,T/2 - b'/2) \quad . \quad . \quad . \quad (1)$$

or $$E_t = b\,T + c\,T^2 - (b'\,T + c'\,T^2)/2 \quad . \quad . \quad (2)$$

This shows that, in the idealised case under consideration, the number of sections does not affect the result.

Now call E_1 and E_2 the thermal E.M.F.'s of the two constituents with the standard metal respectively. Then, by the law of intermediate metals, $E_1 - E_2$ is the E.M.F. between the two constituents, and equation (2) becomes:—

$$E_t = E_1 - \frac{E_1 - E_2}{2}$$

$$= \tfrac{1}{2}(E_1 + E_2) \quad . \quad . \quad . \quad . \quad (3)$$

Next consider the case, as unlikely practically as the first, where the constituents are arranged in rods parallel to the length of the bar, as in Fig. 3, and assume that the wires of the standard metal are in contact with several rods of both constituents. This case is very much more complicated, as we have to consider the effects of currents circulating in the strip.

Consider two strips X and Y, Fig. 4, connected at their ends A and B to an electrometer, potentiometer, or other instrument which takes no current from the system, A and B being at temperatures T and T_0 respec-

* Broniewski, *Annales de Chimie et Physique*, 1912, vol. xxv, page 5.

† Strictly speaking, this is theoretically impossible; but the limits of solubility are sometimes so small as to be practically negligible.

‡ See also Guertler, "Electrical Conductivity and the Constitution of Alloys," Journal of the Institute of Metals, No. 2, 1911, vol. vi, pages 146 and 147.

* This equation is only strictly true over a small range of temperature.

tively,* and V and V_0 being their potentials. Then $V - V_0$ is the E.M.F. which we require to find.

Let v_1 and v_2 be the rise of potential on passing from A to X and to Y respectively, and u_1 and u_2 the fall on passing from X and from Y to B. Also let R_1 and R_2 be the resistances of the circuits X and Y, and C_1 and C_2 the currents flowing through them when a balance is obtained in the potentiometer circuit.

In the circuit through X :

$$V - v_1 - (V_0 + u_1) = R_1 c_1$$

and through Y :

$$V - v_2 - (V_0 + u_2) = R_2 c_2 .$$

But $C_1 = c_2 = C$, say :

$$\therefore \quad \frac{V - V_0 + v_1 - u_1}{V - V_0 + v_2 - u_2} = \frac{R_1 C}{R_2 C}$$

$$\therefore \quad (V - V_0)(R_1 + R_2) = -R_2(v_1 - u_1) - R_1(v_2 - u_2)$$

and if E_1 and E_2 are the thermal E.M.F.'s of X and Y separately with the standard metal, then when R is infinite $C = 0$ and $v_1 - u_1 = -E_1$, while similarly $v_2 - u_2 = -E_2$. Thus :

$$V - V_0 = \frac{R_1 E_2 + R_2 E_1}{R_1 + R_2}$$

but $V - V_0$ is the thermal E.M.F. which we require, *i.e.*, $V - V_0 = E_t$.

$$\therefore \quad E_t = \frac{R_1 E_2 + R_2 E_1}{R_1 + R_2} \quad . \quad . \quad . \quad (4)$$

Hence, if $R_1 = R_2$:

$$E_t = \tfrac{1}{2}(E_1 + E_2) \quad . \quad . \quad . \quad . \quad (5)$$

It will be seen that equation (5) is the same as equation (3); *i.e.*, where the resistances of the constituents are the same, the thermal E.M.F.'s generated by the two arrangements are the same, but otherwise they are different. As this latter will generally be the case, it may be assumed that generally there will be a difference in thermal E.M.F. when the arrangement of the constituents is different.

Where the E.M.F. is measured by a galvanometer or other method which takes a current from the system, it can be shown that for strips in parallel :

$$E_t = \frac{R_2 E_1 + R_1 E_2}{R_1 + R_2 - \dfrac{R_1 - R_2}{R}} \quad . \quad . \quad . \quad (6)$$

where R is the resistance of the galvanometer circuit, the other symbols being as before.

In order to verify the conclusions arrived at above, the following experiments were devised. Strips were cut from sheets of two different metals—in the first case tin and lead—and were rolled together to make a composite sheet of alternating layers. In the case of the lead and tin the rolling was done cold, and then strips were cut from the rolled sheet to give the "parallel" arrangement, discs being also punched out and built up into a rod, having the constituent layers arranged in series. The parallel arrangement consisted of about 30 sheets of lead and tin, about 0·07 mm. thick, while the series rod had approximately 700 discs of each metal of the same thickness as before. To keep the metal in position it was enclosed, in all the experiments, in an ebonite tube as shown in Fig. 5.

The parallel strips were packed tightly into the tube, and were then ground off flush with the ebonite. Caps of the same material, into which were drilled a number of radial holes, were screwed on to the end of the tube. The wires from the thermocouples, referred to below, passed through the holes, and a brass screw was fastened into the top of the cap. At each end was placed an iron-constantan thermocouple, having a soldered junction hammered out to form a thin disc. These were held, by means of the screws, firmly in contact with the ends of the specimen. The series arrangement was the same, except that it was not necessary to grind the ends of the metal. The thermocouples were connected to copper wires, the junctions being made in a thermos flask containing melting ice, and the wires led to a switch so arranged that it was possible to connect either of the couples, or either wire of each couple, to a potentiometer. In this way the temperature at either end, and the E.M.F. due to the specimen against iron or the specimen against constantan, could be measured. A small nichrome-wound furnace was slipped over one end of the tube, and the other end was, in certain cases, exposed to the air, and, in other cases, placed in a copper tube immersed in ice. The method of carrying out an experiment was as follows :

The nichrome furnace was switched on, and, when the temperature was steady, readings were taken of the E.M.F.'s generated by (1) the hot-end couple, (2) the cold end-couple, (3) the specimen-iron couple, (4) the specimen-constantan couple, and (5) the hot-end couple. If (1) and (5) differed by more than a few microvolts the results obtained were ignored. The values obtained under heading (4) were not used except as a check on the readings, the thermo-electric power of the iron-constantan couple being determined from (3) and (4) and compared with the known value.

The results obtained for the lead-tin series were inconclusive, because the thermo-electric power of tin with regard to lead is almost negligible, the actual figures obtained being :—

	Microvolts.
Series lead-tin *versus* iron	11·75
Parallel lead-tin *versus* iron	11·70

The thermo-electric powers of lead and of tin *versus* iron being 11·83 and 11·90 respectively. The results, however, are of value as a check on the accuracy of the method.

It had been hoped to use metals which formed an eutectic with each other, and to compare the results obtained in the method described with those given by a rod made by melting the metals together.* This, as well as the ease of rolling, influenced the selection of lead and tin for the first experiment. It was considered of much greater importance, however, to choose a pair of metals which had a large difference in thermo-electric power, and this, as well as the necessity that they should be readily rolled together fixed the choice on nickel and copper. With the exception of one operation these were prepared and set up, as in the case of the lead-tin experiment. On punching out the discs from the sheet considerable dishing took place, which, in the case of the lead-tin series, was easily remedied by squeezing the discs. The copper-nickel discs, however, were too stiff to be treated in this way. They were therefore mounted with seccotine on a steel disc, and one side was ground flat on an emery-wheel. They were then reversed, and the other side was similarly treated. This was followed by washing and drying to remove the seccotine, any traces which remained after this treatment being removed by a light rub on fine emery paper. The discs, thus prepared, were assembled in the tube as described above. The series arrangement consisted of about 800 discs of each metal 0·07 mm. thick, and the parallel arrangement of about 50 strips of about the same thickness.

Before carrying out the experiment the values for the thermo-electric power were calculated for different

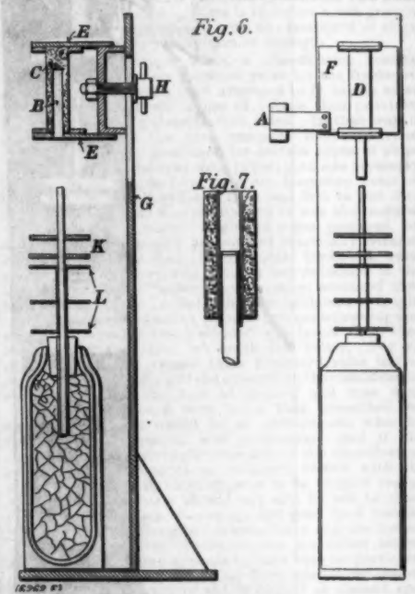


Fig. 6.

Fig. 7.

temperatures from equations (3) and (4), on this and the previous page, and these, together with the values found, are given in the following table :—

Temperature Difference.	Series.		Parallel.	
	Calculated.	Found.	Calculated.	Found.
25 deg. C.	21·3	19·3	14·1	15·4
35 deg. C.	21·1	19·2	13·8	14·0
40 deg. C.	20·9	19·2	13·6	13.7

The values for E_1 and E_2 used in the calculations were obtained from Hadley's "Magnetism and Electricity," and were as follows :—

Temperature.	Copper-Iron.	Nickel-Iron.
25 deg. C.	9·0	32·7
35 deg. C.	9·5	32·7
40 deg. C.	9·3	32·6

The values used for the resistances were copper 1·6, nickel 7·0. The value given for nickel varies very much in different tables, being given in the "Recueil de Constantes Physiques" as varying between 6·9 and 12·3; a low value has been taken, as the higher figures are probably (in some cases certainly) due to impurities in the metal, and that used by the author was a very pure material, supplied by Johnson, Matthey and Co. The variations in the results, due to the uncertainty of the resistance of the nickel, would not be very great, the lower values giving a somewhat better agreement between the calculated and observed values for E in the parallel arrangement, and the higher values giving rise to an even greater difference between the E.M.F. given by the two different arrangements of the metals.

It will be seen that the agreement is quite as good as could be expected, and that a very large difference exists, in this case, in the thermal E.M.F. generated by different arrangements of the same metal.

While it is obvious that the arrangement of the constituents in the layers or strips considered above is purely artificial, and will not occur in practice, yet a slight approach to the series arrangement may occur when a thin bar is turned out of a very coarsely crystalline casting, while a drawn wire may be somewhat similar to the parallel arrangement.

The theoretical reasons underlying the shape of the curve for solid solutions cannot be said to be known. In some alloy systems the curve resembles that obtained by electrical conductivity measurements, the thermal E.M.F. falling rapidly as the second metal is added; but in other cases the curve resembles that of electrical resistance. It has been suggested* that it is possible to explain these results by admitting the formation, in solid solutions, of couples of which the E.M.F.'s are added together, these causing the resulting thermal E.M.F. to vary. The amount of the variation will depend on the nature of the alloy and the number of the couples. It is interesting to note that the existence of couples in a solid solution was invoked by Rayleigh and Liebenow to explain the great increase in the resistance of solid solutions compared with that of their constituent metals. In this case it was assumed that the Peltier effects at these couples caused the increase in the resistance. This theory is, however, no longer held.

In addition to plotting the thermal E.M.F.-temperature curve, it is possible to plot the variation of thermo-electric force against temperature : *i.e.*, the co-ordinates are the temperature T and the ratio $\frac{dE}{dT}$ or the thermo-electric power, as it is called. This curve is stated to give clearer results than that of temperature plotted against E.M.F., but it also shows up errors in experimental data to a much greater extent.

A few of the practical details in the investigation of an alloy system by the measurement of thermal E.M.F. may be referred to here.

1. *Form of the Specimens.*—Where it is possible to draw the alloy into a wire, this is probably the best form of specimen. In the vast majority of cases, however, this is impossible, as very few alloys can be wire-drawn. In such a case the material must be cast into the form of a thin rod, and when this is done the standard metal, which is to form the other element of the thermocouple, may well be inserted into the mould at each end, so that the alloy solidifies round the wire.

Various methods have been used for casting the alloy. Thus Broniewski casts his alloys into a chill mould, the lower end of which is connected to an air pump. Metals with low melting-points can be sucked up into a glass tube. Indeed, any method which will give a continuous rod of metal of sufficient length is all that is required.

2. *The Standard Metal.*—Various metals have been used as the standard whose E.M.F., as a couple with the alloy under investigation, is to be measured.

For high temperature work, platinum is undoubtedly the best metal to use. It has, so far as is known, no allotropic modifications between 0 deg. C. and its melting-point. The fact that it is one of the elements of almost all thermocouples for use at high temperatures is but a recognition of this fact.

For investigations below 300 deg. C. lead has largely been used as the standard metal. The reason for this is that lead appears to exhibit no Thomson effect, and therefore its use reduces the possibility of introducing errors into the observations.

Some investigators use, as standard, a wire made of one of the component metals of the series under investigation.

3. *Method of making Contact between the Standard Metal and the Alloy.*—For comparatively low temperatures the metals may be held together by any convenient form of clamp. For higher temperatures this is not so satisfactory, and various other devices have been employed, such as soldering, arc welding, &c. Where the alloy is of comparatively low melting-point, it is possible to melt the end of the rod and embed the standard into it.

4. *Methods of Measuring the E.M.F.*—There are two methods which have been used for measuring the E.M.F. The first of these consists in using a galvanometer or milliammeter to measure the current generated, and, knowing the resistance of the circuit, the E.M.F. is readily calculated. This method suffers from the grave disadvantage that it is necessary to measure the resistance of the circuit at all temperatures at which the thermal E.M.F. is measured. A far more satisfactory way to measure the E.M.F. is to use a potentiometer, in which case the resistance of the specimen need not be considered. By using a null method, any fear of trouble due to the Peltier or Thomson effects is eliminated, as there is no current flowing through the specimen at the time when the measurement is made.

5. *Maintenance of Temperature Difference.*—Various methods have been used for maintaining a temperature difference, either constant or variable, between the hot and cold junctions. For constant differences one of the junctions is usually kept in melting ice and the other in the vapour of some boiling liquid. For investigating changes of thermal E.M.F. with change of temperature, one of the junctions is generally immersed in melting ice and the other is put into a small furnace. This method,

* The mathematics of this case are due to Sir R. T. Glazebrook, F.R.S., to whom the author is much indebted.

* The results would not, of course, be comparable, owing to the solubilities of the metals in each other in the case of the cast alloy.

* Broniewski, *loc. cit.*

as pointed out by Burgess and Scott,* "possesses the disadvantage of giving the total electromotive force between the cold junction kept at zero and the hot junction immersed in the heated region of a furnace; there may thus be ambiguity or superposition of thermo-electric effects along the wire." This had already been pointed out by Boudouard and Le Chatelier.† Burgess and Scott overcome the difficulty by using very short specimens, which were completely immersed in the furnace in such a way that one end was at a higher temperature than the other, the difference between the two being only a few degrees. The temperature at the hotter end and the thermal E.M.F. were read simultaneously, and the temperature of the colder end was read less frequently. From the results the thermo-electric power was calculated. Benedicks‡ has modified this method by reading the difference between the two ends of the specimen directly on a differential galvanometer, a third couple reading the absolute temperature.

The following is a description of a simple apparatus designed by the author for the purpose of measuring thermo-electric force.

The specimens are made in the form of a rod, about 5 mm. in diameter and from 15 cm. to 20 cm. in length. Where possible this is done by turning them out of cast, or preferably rolled bar; otherwise the liquid metal is sucked up into a silica tube. A very small electric furnace (A, Fig. 6), having an internal diameter a little larger than the rod, is slipped over one end of the latter, which is wrapped in asbestos paper until it is a good fit in the furnace, the rod being in a vertical position. The height of the furnace is adjusted so that the end of the rod reaches to the middle of it, as shown in Fig. 7, page 805. The current is then switched on to the furnace, and in a few minutes the rod commences to melt from the top end, the asbestos paper acting as a retaining wall to prevent the molten metal from flowing away. When about 2 mm. or 3 mm. of the rod have liquefied, an iron-constantan, or platinum-platinum-irridium couple, is inserted into the molten metal and the current switched off. In a very short time the metal sets round the couple, and the rod and couple can then be withdrawn from the furnace. A similar couple is then fixed in the same way at the other end.§ The furnace itself consists of a silica tube 40 mm. long and 7 mm. in internal diameter, on which 25 ohms of No. 40 nichrome wire are wound. A strip of asbestos paper is wrapped over the winding, making the outside diameter of the furnace 17 mm. a piece of aluminium sheet, slightly wider than the length of the furnace, keeps the asbestos in place, and the ends of the furnace are finished off with a layer of Purimachos cement. This particular apparatus has only been used at comparatively low temperatures (about 700 deg. C.). For higher temperatures it would probably be advisable to increase the thickness of the lagging.

For temperatures not much exceeding 700 deg. C., which represents the limit to which the apparatus has been used, an iron-constantan couple can be employed, and in this case the iron wire of the couple serves a twofold purpose, acting both as the standard metal against which the thermal E.M.F. of the alloy under investigation is measured, and also as one element of the couple which measures the temperature of the alloy. It will be seen that the thermal E.M.F. and the temperature are thus measured at exactly the same point, which is very important, particularly in the case of short specimens, owing to the very large temperature gradient which must exist in the alloy, and which renders accurate temperature determination by means of a couple placed near the junction very problematic.

When one junction is kept at zero by immersing in ice, the constantan wire at that end can be dispensed with, and the iron wire alone, or indeed any wire, used. This has usually been done with this apparatus, the lower end of the rod, carrying the iron wire, fitting into a glass tube, which is immersed in melting ice in a thermos flask. The wire, which passes up the tube with the specimen, is insulated from the latter by means of mica or shellac varnish.

The upper end of the specimen, in which are embedded the iron and constantan wires, fits into a small electric furnace. This furnace, whose dimensions can be seen in Fig. 6, consists of a small fireclay tube B, closed at one end and wound with No. 40 S.W.G. nichrome wire. An asbestos lagging C covers this, and the whole is encased in a brass tube D, fixed between uralite sheets E The furnace is carried on a wooden base F, which is clamped to the stand G, by means of the thumbscrew H, moving vertically in a slot in the stand. This enables the height of the furnace to be adjusted so as to bring the top of the specimen into the hottest part. (It will be seen that this base also carries the little furnace A, which is used in the operation of fixing the wires to the rod.)

The two iron wires and the constantan wire are connected, *via* a thermos flask containing ice, and copper leads, to a potentiometer, by means of which the E.M.F. given by the iron-constantan and the iron alloy couples can be measured. As the values of the former in terms of temperature are known, the temperature-E.M.F. curve or the temperature thermo-electric power curve can be plotted from a series of such observations.

Directly under the furnace, and sliding on the rod, are two uralite discs K, which screen everything below them from direct radiation from the furnace. Three brass discs L, soldered on to a tube which fits closely on to the rod, help to dissipate the heat which is conducted down the alloy, and thus economise in ice and help to ensure that the cold junction of the system is really at zero.

Owing to the small amount of lagging this furnace is very inefficient, and would probably require modification for high temperature work, but where it is not necessary to go above, say, 700 deg. C., the rapidity with which any temperature can be attained, and the ease of regulation, render it very suitable for the work for which it was designed.

Fig. 8 is a photograph of the apparatus.

* Burgess and Scott, Journal of the Iron and Steel Institute, vol. xciv, page 258.

† Boudouard, *Revue de Métallurgie*, vol. i, page 80; Le Chatelier, *ibid.*, vol. i, page 134.

‡ Benedicks, *Comptes Rendus*, vol. clxii, page 979.

§ The annealing, which must be given to the specimen to ensure the attainment of equilibrium, will, of course, be carried out after the wires have been fixed in position

APPENDIX.

The Seebeck, Peltier, Thomson and Benedicks Effects.

The first three of these effects are very well known, and are described in all text books on electricity. A knowledge of what they are and, more particularly,

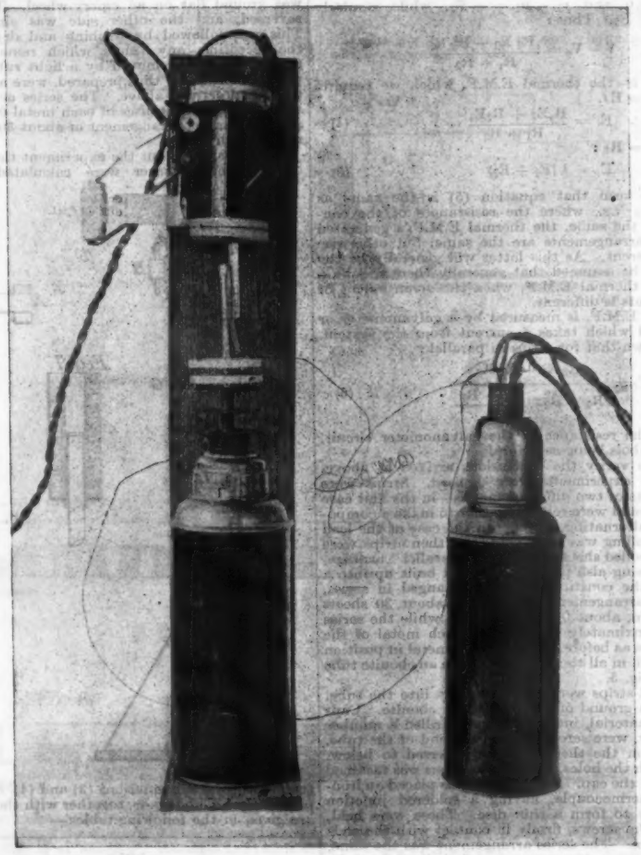


FIG. 8.

of the errors that the two latter may introduce in determinations of thermal E.M.F., is so important in the application of the method to metallographic investigation that no apology is necessary for describing them here.

The Seebeck Effect.—This effect was first observed by Seebeck, of Berlin, in 1821. It is the fundamental phenomenon underlying all thermo-electric observations and has been briefly described in this paper.

The Peltier Effect.—If a current is sent through a circuit consisting of two different metals, heat is generated at one junction and absorbed at the other. Call the metals A and B, and the junctions t and t'. If t is the junction which, on being heated, will cause a current to flow from A to B through t, then on sending a current in this direction through the circuit heat will be absorbed at t (i.e., it will become cooler), and will be generated at t'. On reversing the current, t will be cooled and t' heated. The energy generated or absorbed is:

$$\eta = P C t$$

where C is the current, t is the time, and P is the Peltier coefficient. This has a value:

$$P = T \frac{dE}{dT}$$

where T is the absolute temperature, and $\frac{dE}{dT}$ the thermo-electric power of the couple. The Peltier effect is explained by assuming that at the junction of two metals there is a sudden change of potential, the Seebeck effect, by assuming that alteration in temperature alters this potential difference.

The Thomson Effect.—If a current is passed through a uniform, homogeneous conductor in which a temperature gradient exists, heat will be generated on one side of the heat maximum and absorbed on the other. Which side the heat is generated depends on the direction of the current and on the material of the conductor. Imagine a wire A B C made of copper, antimony, zinc, cadmium, or silver, the point B being at a higher temperature than A or C, and carrying a current flowing from A to C. Then heat will be absorbed in the region A B, and generated in the region B C. Should the conductor be made of platinum, iron, bismuth, nickel, cobalt or mercury, the effect is reversed. The first case is known as the positive, and the second as the negative, Thomson effect. The energy generated or absorbed between two points is:

$$\eta = C t \sigma d T$$

where C is the current, t the time, σ a coefficient, and dT the difference in temperature between the two points. The term σ is called the Thomson coefficient, and has the value:

$$\sigma = T 2 c$$

where T is the absolute temperature and c is the coefficient in the second term of Avenarius' equation.

The Benedicks Effects.—Benedicks has recently shown the existence of two effects connecting heat and electricity, one of which is claimed to be the general case, of which the Thomson effect is a particular case. The first of these may be stated thus: In a homogeneous metallic circuit an asymmetric distribution of temperature gives rise to an electromotive force.*

This effect can be shown by welding together two platinum wires (just in contact) in the form of a cross. Two adjacent arms of the cross are connected to a galvanometer, and one of the others is heated by means of a minute gas jet. Owing to the very small cross-section at the weld there is a very steep temperature gradient across the junction of the two wires, and a thermal E.M.F. is generated between them which sends a current through the galvanometer. Benedicks has constructed a small motor which, when placed in a magnetic field, is caused to rotate by means of the current generated by this effect. The E.M.F. obtained in this way may be of the same order as that obtained with the alloys used in the manufacture of thermocouples. Thus, with tungsten the value of the Benedicks effect is about 21 microvolts per degree, while with a platinum-platinum-rhodium couple it is about 11, and with an iron-constantan

* Benedicks, *Comptes Rendus*, 1916, vol. clxiii, page 751, and *Revue de Métallurgie*, 1918, vol. xv, page 329.

couple about 50 microvolts per degree. In the case of ferro-silicon containing 50 per cent. of silicon, it is stated that the least change of temperature near the point of contact gives rise to enormous variations in the E.M.F.

The second effect* which Benedicks has observed is the converse of the above; i.e., if through a conductor at a constant temperature containing a symmetrical constriction a current is passed, heat is absorbed on one side of the constriction and generated on the other.

The paper is published in a very condensed form, and the description of the experimental data is not easy to follow. Benedicks provisionally terms this effect the "X" effect, and suggests that as the Thomson effect is a special case of this, the two together should be called the Kelvin effect.

An interesting example of the magnitude of the error which can be introduced by the Peltier and Thomson effects, into measurements of thermo-electric force, came under the author's notice while carrying out some determinations of the temperature-E.M.F. curve of pure zinc.

The circumstances were rather exceptional, as it happened that all the errors were additive, and that their sum was doubled by the method of operation. The standard metal used was iron, and part of the E.M.F. (to the nearest 200 microvolts) was balanced by means of a potentiometer, the residual amount being read by the galvanometer deflection. This deflection was kept as small as possible, and the readings were taken sometimes on one side and sometimes on the other of the zero position. Let us now consider the results of the Peltier and Thomson effects when the current is flowing from the zinc to the iron through the hot junction.

Peltier Effect.—At the hot junction of an iron-zinc couple the zinc (at the temperature under consideration) is at a higher potential than the iron, and consequently the current will tend to flow from the zinc to the iron. This is the direction of the current we are considering, and therefore heat will be absorbed at the junction.

Thomson Effect.—(1) In the iron. The current is flowing through the iron from the hot to the cold part. Iron having a negative Thomson effect, heat will be absorbed. (2) In the zinc. Here the current is flowing from the cold to the hot part, and the coefficient of the Thomson effect being positive for zinc, heat will once more be absorbed. It will be seen that the Peltier effect and the Thomson effect, in both the iron and the zinc, all combine to cool the junction when the current is flowing in the direction indicated above. They will also combine to heat the junction when the current is flowing in the opposite direction. A reversal of the current will therefore double the effect. Readings were taken on the potentiometer to the nearest 200 microvolts on each side of the true reading. Thus suppose the E.M.F. was 280 microvolts, one reading was taken with 200 and another with 400 microvolts balanced. The galvanometer readings should, of course, be + 80 and − 120 respectively, the current flowing in opposite directions in the two cases. The following are a few observations taken in this way. θ is the reading of the iron-constantan couple in degrees Centigrade, and E_1 and E_2 the two readings of the potentiometer and galvanometer, the current being in opposite directions in the two cases.

θ	E_1.	E_2.
324	215	230
328	192	215
332	160	195
337	145	167
340	120	140
344	100	123

It will be seen that with the current in one direction the reading is approximately the same as that at a temperature 4 deg. higher with the current reversed. It is doubtless unusual for all three factors to be additive, but this example shows the advantage of a null method over one in which galvanometer deflections are used.

The author is very much indebted to Sir Richard T. Glazebrook, C.B., F.R.S., and to Dr. W. Rosenhain, F.R.S.; to the former for the interest he has taken in the work, and for the calculations as to the E.M.F. generated in the parallel arrangement of the two constituents, and to the latter for much useful advice and criticism, and for having drawn the author's attention to the latter of Benedicks' papers. He also wishes to thank Miss K. E. Bingham, B.Sc., for her assistance in the experimental part of the work.

FREEBOARD AND STRENGTH OF SHIPS.†

By J. Brunn, D.Sc., Member.

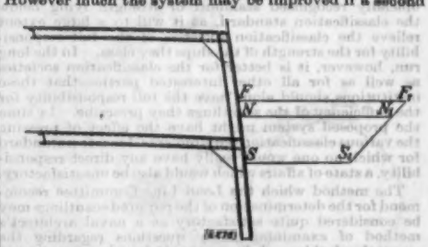
From the point of view of the safety of the passengers, crew and cargo, it is of little importance whether a ship founders for want of freeboard, stability, watertight subdivision or strength. It is therefore equally important that a ship should be in possession of a sufficient amount of each of these four qualities. From the point of view of the necessity for Government control their importance is nevertheless in a different position. In practice, it has been found that ships are to a sufficient extent assured of having the required amount of stability by leaving it to the shipbuilders to produce a vessel that can be suitably loaded so as to be in possession of the necessary stability and by leaving it to the master of the vessel to see that she is properly loaded. On the whole this method of ensuring that ships are in possession of sufficient stability has been satisfactory, and Government control has been unnecessary, which is well, as it would be exceedingly difficult to devise a method which would give greater safety than this one, where the responsibility for the stability rests entirely on those who, when the stability is needed, i.e., when the ship is at sea, can alone control the factors governing it. Statutory regulations regarding the stability of ships would also, if they were at all practicable, not be particularly needed, because stability is not a property the increase of which reduces the earning capacity of a ship. The question of the watertight subdivision of cargo ships has been left to the classification societies and shipowners. Here an increase of safety, i.e., a shortening of the holds, goes against the owners' economical interests, and Government control may therefore be desirable, and it can in this instance, if found necessary, be applied without difficulty. With regard to the question of strength there is always a temptation for an owner of a ship to try to reduce unduly the amount of structural material in order to increase the deadweight or the earning capacity of the ship. The influence of the shipbuilder and the classification society will, as a rule, be a hindrance to an owner going too far in this respect, but apart from this the temptation to reduce unduly the strength of a ship occurs practically only once, viz., when the ship is being built, and even then in a not very acute form with an immediate economical gain in sight. It is quite otherwise with regard to the loading of a ship. An owner has here always a much greater temptation to go too far than in the case of the strength. The draught can, after the vessel is built, easily be increased for the particular voyage or from time to time as competition may indicate the desirability of such a proceeding, until the safe limit is ultimately exceeded. There is therefore much greater need of Government control with the freeboard of ships than with stability, subdivision or strength.

It was only natural when a classification society (Lloyd's Register) first proposed rules for the freeboard of ships, that the rules were arranged to fit in the most convenient manner the types of vessels then provided for in the society's classification rules. In that way it came about that the first complete freeboard rules prescribed a larger freeboard for certain types of ships (viz., the awning and spar-deck types) than was necessary from a height of platform or spare buoyancy point of view. When the Board of Trade had first to put into force statutory load-line regulations it was also natural that the very complete freeboard rules prepared by Lloyd's Register should be adopted practically without alteration. These first Government freeboard rules might, however, very well without any reduction in the general standard of safety have been so arranged that they only prescribed a real minimum freeboard or height of platform for all vessels. If in certain cases (awning and spar deck vessels) the freeboard was larger than that required by the rules, so much the better. For all ordinary types of vessels these freeboard rules left in practice the controlling of the strength to the classification societies. If, in the case of awning and spar deck vessels, the freeboard were larger than prescribed, all that was required would be an arrangement whereby the necessary strength was guaranteed, and if the controlling of the strength were left to the classification societies in the case of all ordinary vessels with the minimum freeboard, there appears to be no good reason why the same control should not also be left to these societies in the case of awning and spar deck vessels, where the only difference between them and the former vessels was that the freeboard was somewhat larger. In other words, there appears to have been no particular necessity for Government to lay down special regulations for the determination of the freeboard of classed spar and awning deck vessels.

The principle of practically leaving the control of the strength of ships to the classification societies in the case of all vessels having the minimum freeboard permitted by the load-line regulations and of having certain Government regulations for the strength of vessels with larger freeboard has been incorporated from the British rules into the freeboard rules of all other countries, mainly, of course, because the British rules were the older ones, and they have therefore served as a pattern for the others, but to a certain extent no doubt also because the various national classification societies, which administer the rules found such an arrangement convenient, as these institutions would otherwise be compelled to have a similar arrangement of their own for dealing with the vessels having a larger freeboard than the minimum permitted by the Government rules, just as Lloyd's Register had before there were Board of Trade freeboard rules. The principle is nevertheless not a very rational one. The original idea in Lloyd's Register freeboard rules was that the extent of loading of the various types of vessels such as flush deckers, spar deckers and awning deckers should be in proportion to the strength of their hulls. This idea was, of course, sound enough and could be carried out satisfactorily in practice as long as the assigning body used the same standard of strength for all three types of vessels. The Board of Trade standard (Lloyd's Rules of 1885) stood practically unchanged for thirty-five years. During this time experience showed the necessity of making many alterations and additions to the classification rules.

The consequence of this has been that the latter rules in many cases call for greater strength than the Board of Trade rules. The classification society's rules were applied to all ordinary full scantling types of vessels (flush deckers, three-island vessels, &c.). If these rules had been applied consistently in the same manner to the other types (spar and awning deck vessels) then the original idea that the loading should for all types be in proportion to the strength could have been carried through. It became, however, the practice of the assigning bodies to deal with spar and awning-deck vessels (or practically all vessels classed "with freeboard") on the lower Board of Trade strength basis. The result was that the additions which the classification societies in the course of time had made to the scantlings of these vessels to a large extent became illusory as the draught could, in accordance with the Government regulations, be increased correspondingly. The standard of strength of these vessels was thus in reality lower than that of the ordinary types of vessels, in the proportion in which the requirements of the 1885 rules were below those of the present rules. One consequence of this anomaly is the well-known fact that a shelter-deck vessel can, according to the Board of Trade regulations, when the tonnage opening is closed, suddenly be immersed 2 ft. to 3 ft. deeper in the water without any increase of the scantlings, because when there is a tonnage opening such a vessel is dealt with on the basis of the regular classification rules, and when there is no tonnage opening she is dealt with on the lower Board of Trade standard.

Freeboard rules in the narrow sense of the term are of the kind which it is particularly desirable should be uniform in all countries so as to ensure a uniform standard of safety and a fair international basis for competition with regard to carrying capacity, and freeboard rules are at the same time of a nature which makes them comparatively easily adaptable for international use. It is otherwise, however, with the question of strength. An international application of strength regulations is not nearly so necessary as an application of pure load-line regulations, and it is not nearly so easy, at least until universal classification rules may be adopted. The proposal of the British Load Line Committee of 1915 is, as regards the rules for the minimum freeboards of vessels, probably the best that could be made as a basis for an international agreement on this point. On the question of the relation of freeboard to strength, the committee seem on the other hand to have been afraid to deviate too much from the established order of things. However much the system may be improved if a second



standard of strength, which must necessarily be a lighter one, is introduced in addition to the classification standard, there will still be anomalies. The committee's proposed method of dealing with the strength question cannot therefore, in spite of the many improvements in details (as compared with the earlier method), be considered as a very satisfactory one, particularly if it is to be used internationally. There appears in reality to be no very strong reason why detailed regulation regarding the question of strength should not be left out of international freeboard rules. Such regulations cannot under any circumstances provide a guarantee of the safety of a ship in every respect. They ought, and practically can, only provide a statutory security against one particular danger, viz., undue overloading. The question of the stability of the vessel is, for instance, necessarily left entirely to the care of the master, and when, from the point of view of safety, so important a property as the stability of the vessel can be left out of consideration in assigning the load line, it would appear that the strength of the vessel might with equal safety be left out of consideration in this connection.

It may, however, be expedient to make some reference as it is no doubt expedient to make some reference to the question of stability such as that proposed by the British Load Line Committee. In the first place it might be made clear that the freeboards prescribed are the absolute minima. Secondly, it might be stated that all vessels allowed to load to these freeboards are to have at least the scantlings required by a recognised classification society. A requirement of this nature would, as regards its results, be in accordance with the present practice in all countries having load-line regulations. Thirdly, there might be a regulation to the effect that the standard of strength for all vessels with a higher freeboard than the minimum laid down in the rules shall not be less than that required by the particular assigning society for vessels of the full scantling type. In that way each classification society would have only one minimum standard of strength for all first-class seagoing vessels, and the society itself would be entirely responsible for the upholding of this standard, both for the full scantling types and for the lighter scantling types, whereas by the present practice the classification society is really only fully responsible for the strength of the full scantling vessels, the strength of the vessels with reduced scantlings being regulated not entirely by the society's own rules, but more or less by the legal load-line regulations. It is very desirable that the strength required for any given draught or freeboard should be clearly laid down. The British Load Line Committee propose that there shall be provided freeboards for two types of vessel, the flush deck one and the complete superstructure one. The principle is a very convenient one, and it will no doubt be adopted internationally. In Norway such a practice has, as a matter of fact, been used for a long time. Probably all classification societies have already got rules for the scantlings of these two types of ships. All

* Benedicks, *Comptes Rendus*, 1918, vol. clxvii, page 296.

† Paper read before the Institution of Naval Architects, March 25, 1920.

that is necessary in order to obtain a regulation ensuring a uniform application of strength requirements for each society would therefore be a statement to the effect that the scantlings for vessels with freeboards falling between that of a flush deck vessel and that of a superstructure vessel are to be obtained by direct interpolation between the scantlings required for the flush deck vessel and the scantlings required for the superstructure vessel. Let S and F, Fig. 1, be the respective positions of the load lines for a superstructure and a flush deck vessel, and let $S S_1$ and $F F_1$ represent the dimensions or numbers which the classification society in question use for the determination of the scantlings of the superstructure and flush deck vessel respectively. For any intermediate position of the load line, say N, the dimension or number regulating the scantlings will then be $N N_1$. The scantling requirements under such a regulation will therefore be as completely specified for a vessel with an intermediate freeboard as they are for the two standard types, and some such method will probably be necessary if the original idea of uniform strength in proportion to draught is to be carried out in a satisfactory manner in practice. In Norway such a procedure has been established for some time.

The method proposed by the British Load Line Committee of dealing with the strength question involves in reality a fixed standard of strength apart from the current classification regulations. It is in this respect no better than the previous method based on the strength standard of 1885. From the manner in which it is arrived at, viz., as a sort of minimum of the minima of the classification requirements, it follows that the standard will, like the previous one, be below the current practice. A vessel may therefore under the proposed method be built with the classification scantlings required for a certain lighter draught and may then, just as under the present regulations, claim to be allowed to load to a deeper draught, viz., that which the proposed Government freeboard standard of strength would allow. It may, of course, from a narrow classification society point of view be considered satisfactory to have such an officially recognised standard of strength lying below the classification standard, as it will to a large extent relieve the classification societies of the full responsibility for the strength of the ships they class. In the long run, however, it is better for the classification societies as well as for all other interested parties that these institutions should alone have the full responsibility for the sufficiency of the scantlings they prescribe. In time the proposed system might have the effect of pressing the various classification requirements down to a standard for which no one would really have any direct responsibility, a state of affairs which would also be unsatisfactory.

The method which the Load Line Committee recommend for the determination of the required scantlings may be considered quite satisfactory as a naval architect's method of examining many questions regarding the strength of ships. I have myself in two papers read before the Institution of Engineers and Shipbuilders in Scotland, in 1902, and 1905, recommended very similar methods for such purposes of comparison. The method is, however, not satisfactory when it is a question of establishing a fixed legal standard of strength, particularly an international one. It is quite clear that such a method cannot take account of all the factors affecting the correct and complete determination of the minimum strength required. It cannot therefore be scientifically right that it would be exceedingly undesirable to fix a method of this kind in a rigid legal form which could not be altered for a long term of years to rectify the faults, which would be sure to be discovered in course of time in the same manner as faults have been discovered in the previous load-line regulations, and as faults are discovered even in the best of classification society's rules. It is quite impossible with such systems to foresee all the conditions which may affect the problem. If a method such as the one proposed by the Load Line Committee were established internationally, it would soon be looked upon as a scientifically correct way of estimating the strength of ships, and as it would become unalterable, like the laws of the Medes and Persians, it would come to be a hindrance to progress towards using more correct methods.

From a scientific point of view there may even now be raised several objections in details against the proposed method. It assumes that the moment of resistance principle is sufficiently free from faults to stand as the main basis for strength estimates. This principle is, however, far from correct for so complex a girder as that of a ship's hull, and in the manner in which it is proposed to be applied it ignores, amongst other things, the component effect of the local straining actions in the same or another plane than the main one. The important bending and buckling tendency of the deck and bottom plating is thus ignored. In determining the moment of resistance for longitudinal strength the form of the midship section is ignored, with the result that a ship with a high rise of floor would be required to have even thicker plating than one with a flat bottom, which would not be in accordance with the lessons of experience. Two very important factors are also ignored, viz., the nature of the trade the vessel is engaged in and the distribution of weights. At present classification societies also ignore these factors, but they ought to be taken into account as time and progress make it possible to do so. The Norwegian Classification Society and the Norwegian Board of Trade have, as a matter of fact, to a certain extent already taken these factors into consideration. In estimating the transverse strength the plating is ignored in the determination of the moment of resistance of the frames. This will give very misleading results as to the comparative values of the various forms of frame sections. Channel bars or frames with very heavy reversed bars would thus appear too, to be strong compared with bulb angle frames. A number of other more or less important factors are ignored in dealing with the transverse strength, such as the effect of the vessel's breadth, spring, bulkheads, stiffness of bottom and deck construction, the form of the vessel (curvature of frame), effect of size of lower deck beam knees, &c. The stiffness of the ship (metacentric height) is also an important factor, when it is a question of determining the proper minimum transverse strength of ships. It does not figure directly in the classification societies' rules for the determination of the scantlings of frames, floors, &c., but it is indirectly there to a certain extent, as the scantlings prescribed for sailing vessels without bulkheads, for instance, very distinctly assume that the stiffness deviates but little from the normal for such vessels, otherwise the strength would in many cases be quite insufficient. There is in the Load Line Committee's proposal no standard of strength at all for the deck (beams) and bottom (floors) of ships, although both these parts are very important, in fact, just as important as the sides of the vessel and, as far as the bottom is concerned, just as closely related to the draught or freeboard of the vessel. The above points are sufficient to show that the proposed system is not scientifically quite satisfactory.

There are also, from a practical point of view, objections to the proposed method of dealing with the question of strength. In reality this method means the establishing of a second system in addition to the classification society systems of determining the scantlings of ships. It is clear that the required scantlings could for the items in question very well be produced by some such method as the one proposed, just as satisfactory scantlings might, owing to the great similarity in the proportions of ships, be produced by many other methods than those adopted by the various classification societies. The question is therefore whether the new system is necessary or is a better one than the old one. It might, from the point of view of public safety, be necessary to introduce a new method, if the previous one did not provide sufficient strength. But the proposed system being a minimum of the present minima leads to less strength than is now required. There can, therefore, from the point of view of *safety*, be no necessity for it. Moreover, if the proposed system were required from the point of view of safety, it ought to be reasonably complete and provide the required strength for all those parts the weakness of which might affect the safety of the ship, in the same manner as the present classification methods do. It is, however, by no means complete. There is thus, as already pointed out, no provision at all for the strength of the bottom or decks, nor for the strength longitudinally and transversely at the ends of the vessel. If a ship breaks down for want of strength in the bottom or at the ends, the consequence will of course be very much the same as when she breaks down for the want of longitudinal strength amidships. Again, there is no provision as to what rivet attachment is required for the various parts of a vessel. Experience shows that with the present practice it is usually in the rivet attachments that weakness occurs, and it would therefore, from the point of view of safety, be particularly desirable that a minimum safe basis for the amount of riveting required should be provided. The Load Line Committee do not mention either what is to be done with wood and composite ships, which is particularly regrettable seeing that many ships of this type have lately been built, and these would also be in need of strength. Nor are old ships provided for. It may be argued that all these points will be looked after by the assigning bodies, and that, no doubt, is so. In practice all these points must of necessity be looked after by these bodies, and, moreover, the probability is that the same bodies will look after the strength in their own way, even where the proposed load-line regulations prescribe scantlings. In fact, the classification societies' requirements would be absolutely necessary in addition to the proposed method, but then the latter could not be a better or even a satisfactory method. As the classification societies' methods are the more complete, the proposed one would, in fact, be unnecessary. The introduction of another system in addition to the classification societies' system would mean that there would be two systems for the determination of the same thing, viz., the proper scantlings of ships, and this would further mean that shipbuilders and designers would have to work out the scantlings of ships according to both systems, which would involve an unnecessary waste of time. It might be that the classification societies would attempt to draw up their regulation in such a way that their scantlings always came out in excess of those required by the legal regulations. In that case shipbuilders and designers could, when using the classification regulations, be sure that they were on the right side. But the other regulations would then serve no practical purpose.

From the practical application point of view the proposed principle of only requiring certain moments of resistance and not specifying definite scantlings is unsatisfactory and will, particularly if it should be applied to international practice, cause many questions to be raised as to which form of frame section, thickness of web, width of flanges, &c., should be required.

From the way in which the formulæ proposed by the Load Line Committee are arrived at, they must, as stated above, necessarily lead to insufficient strength. An examination of the scantlings which would be satisfactory according to the proposed method will confirm this. A comparison with the scantlings which experience has shown to be necessary for the trades of Norwegian ships proves also that the proposed strength is, at least in this case, insufficient, and it would therefore be quite indefensible to adopt the proposed standard of strength as the legal standard for Norwegian ships.

Most classification societies have up to the present based their scantling requirements for ordinary ships on the dimensions of the vessel and have ignored the draught in this connection. This is convenient, as the draught is a less definite quantity than, for instance, the depth of a vessel. There is, however, in principle no reason why the draught should not enter into the determination of the scantlings, but it would be most rational that it should do so by being incorporated directly into the particular system used by the assigning body in question, otherwise anomalies cannot be avoided. An example of how such an incorporation may be effected was shown above.

The main object of Government regulations regarding the strength of ships in connection with the assignment of freeboard ought to be to provide an adequate margin of safety for passengers and crew. This object can hardly be achieved by the regulation proposed by the Load Line Committee. It may, nevertheless, be that the proposal is the best possible for British conditions, taking every circumstance into consideration, but the conditions are different in other countries. My object in reading this paper has been to raise, if possible, a discussion on the subject where the voices from other countries can be heard, before a method of dealing with the strength of ships could be established internationally, and I hope my friends on the British Load Line Committee will not take offence at my criticism of this particular point in their report.

CATALOGUES.

Electric Lamp Holder.—Messrs. Lesco, Limited, King-street, Manchester, send a catalogue of their lamp-holder and a copy of the wiring instructions.

Leather Belting.—A priced list of leather belting, in single-ply, from ¼ in. to 12 in. wide, and in two-ply from 2 in. to 40 in. wide, comes from Messrs. John Tullis and Sons, Limited, Glasgow.

Bundling Presses.—Hydraulic presses for bundling scrap metals, and rack and pinion presses for bundling waste paper, are shown in catalogues issued by Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham.

Electric Switches.—A catalogue of "mistake-proof" switch cut-outs comes from the British Insulated and Helsby Cables, Limited, Prescot, Lancs. The construction prevents the opening of the fuse cover while the switch is on, and also switching on while the cover is open.

Cutting Machines.—A catalogue of powerful machines for punching, shearing and cropping steel plates and bars, comes from Messrs. Craig and Donald, Limited, Johnstone, near Glasgow. Some are specially adapted for cutting and bevel cropping angles, tees, channel, joists and other sections. Single and multiple-action types are included, and all are built with steel plate frames.

Water Heaters.—A series of 2, 4, 6 and 8-pass water heaters are the subject of a special catalogue received from the Griscom-Russell Company, New York. The water is heated while it passes through tubes enclosed in a chamber in which they are surrounded by exhaust or other steam. The heaters are suitable for factories or hotels, or for boiler-feed water. A considerable range of standard sizes is made.

Marine Engines.—A book of 76 pages containing over 50 large illustrations, gives an impressive idea of the extent and completeness of the North-Eastern Engineering Company's works at Wallsend-on-Tyne and at Sunderland. The works are now capable of completing marine engines, boilers and auxiliary machinery at the rate of 250,000 h.p. a year. A few illustrations of the company's products, which include oil engines as well as steam engines, are included.

Telephones.—A very complete and well-arranged series of six catalogues dealing with telephones comes from Messrs. James McMillan and Co. (formerly The Ericsson-Bell Telephone Company), Clun House, Surrey-street, London, W.C. 2. The instruments, parts for renewals, and general supplies for all kinds of special installations, from single office or domestic sets to multiple sets suitable for large works, stores, &c., are fully described, illustrated and priced. Special sets for mining, street and diving work are included.

Conveying Machinery.—A catalogue of conveying and transporting machinery made at Messrs. Fraser and Chalmers Engineering Works, Erith, Kent (Proprietors: The General Electric Company, Limited), shows a very extensive application of the conveyor belt system to the handling of ore, limestone, coal and many similar materials of a rough and heavy nature. The conveyors are applied to shipping, stacking, feeding coke ovens, supplying boiler houses, carrying coal and ore, hand picking, and many other uses. Illustrations are given of a number of very large installations completed at home and abroad.

SWEDISH IMPORTERS AND GERMAN EXPORT PRICES.—According to a Swedish authority, referred to in *The Board of Trade Journal*, export prices at the recent Leipzig Fair amounted to as much as 600 per cent. to 1,000 per cent. above prices for the home market. Many Swedish would-be buyers are said to have been so coldly received by their old connections in Germany that they preferred to return without doing business. No improvement is expected, as German houses began to charge their goods in Swedish currency as from April 15. This means a severe blow to Swedish importers, the majority of whom had already bought their requirements of German marks for the whole of this year. As from May 15 it is stated that payment for all German exports will be demanded in the currency of the purchasing country.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

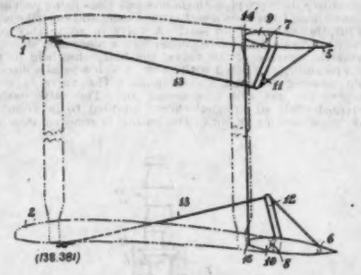
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

138,381. F. Handley-Page, London. Control Elements. (2 *Figs.*) October 2, 1918.—The invention relates to elevator and like control surfaces of aircraft. The said control surfaces, such as the rudder, elevator and ailerons, are pivoted about an axis situated at a greater distance from the trailing edge of the fixed surface than the thickness of the said trailing edge, and are also shrouded by this, within the maximum arc described by the leading edge of the said control surface. The supporting planes of an aircraft 1 and 2 are cut away to receive the aileron control



surfaces 5 and 6. These surfaces are hinged at 7 and 8 so that portions 9 and 10 project beyond the pivotal axis and serve, therefore, to balance the control surfaces about the pivotal axes 7 and 8, whereby the effort of operation is reduced. These parts 9 and 10 are curved or tapered so that their leading edges 14 and 15 never project into the air stream, but are constantly shrouded by the trailing edge of the planes 1 and 2 ahead of them. The ailerons 5 and 6 are provided with king posts 11 and 12, which are both arranged to project inwards towards one another and support the control cables 13. (*Sealed.*)

139,034. F. M. Green, Coventry, J. Lloyd, Coventry, and the Siddeley-Deasy Motor Car Company, Limited, Coventry. Aeroplane Framework. (2 *Figs.*) March 20, 1919.—This invention relates to fittings for the metal framework of aeroplanes. According to this invention, the fitting comprises a tubular clip, which is mounted upon one tube, and is provided with lugs to which is pivoted a second tube or tubes and a bracing wire or tie rod at each side thereof, whilst another tube may be pivotally attached to an eyebolt, passing diametrically across the clip and tube to which it is attached. The clip A is made of a strip of sheet metal, which may be steel or duraluminin, rolled to form a tube, and the ends A^2 of the strip are brought together and secured together, with or without an intermediate packing-piece B. These ends project radially and form a rib, which is shaped to constitute a number of lugs or eyes C. To the extreme pair C, tie rods D are attached, and to the middle one (or middle ones) is secured a tube (or tubes) E, by means of a pin E^2. The

Fig. 1.

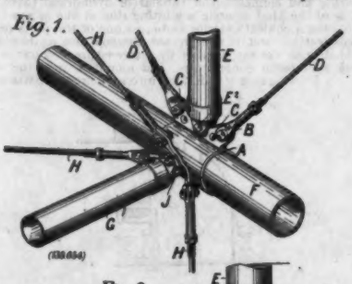
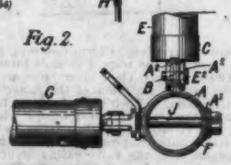


Fig. 2.



clip A is attached, as by sweating, to a main tube F which would generally be a longitudinal tube, and the subsidiary one E, or ones, would lie vertically or approximately so, as shown. As stated, any suitable number of tubes such as E may be attached to the clip A, and these could be arranged in various positions through a certain angular range with regard to the main tube F, but in the same plane as the tube F. The tie rods D may similarly occupy various angular positions, but they would lie radial, or nearly so, to the centre line of the joint, so that their attachment causes little or no bending moment upon the joints. One or more subsidiary tubes G in other planes, and the corresponding tie rods H, are not so highly stressed, and they may conveniently be attached to an eyebolt J passing diametrically across the tube F. The metal at A^3 around the holes for the reception of this bolt may be thickened up, as by brazing metal to the surface of the clip. This through bolt also serves to assist in securing the clip A to the main tube F, and the clip need not, therefore, be sweated in place. (*Sealed.*)

AGRICULTURAL APPLIANCES.

139,054. Ransomes, Sims and Jefferies, Limited, Ipswich, and H. Tunnard, Kirton, near Boston. Ploughshares. (4 *Figs.*) April 4, 1919.—The invention relates to improvements in ploughs and other agricultural implements. According to the invention, to a cranked axle carrying the land or furrow wheel of a plough is secured an arm, which engages with a bayonet slotted link whereby the shares or the like can be held out of work when lifted, and means for adjusting the position of the said arm to regulate the depth of work are provided. 1 is the frame upon which is mounted a cranked axle 2 carrying a land wheel 3, and cranked axle 4 carrying a furrow wheel 5. The axle 2 is secured to an arm 6 having a stud 7 which engages with a bayonet slotted link 8 pivoted at 9 to a bracket 10, mounted on the frame 1. 11 is a trip lever fast on a cross-shaft 111, which lever can engage with the slotted link 8, whilst a separate arm 112 on the cross-shaft 111 is connected to a rod 12, whose other end is connected to an arm 13 pivoted to the frame 1

Fig. 1.

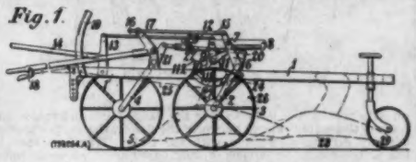
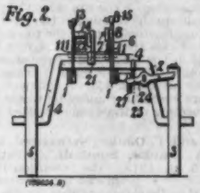


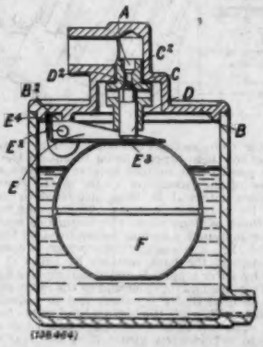
Fig. 2.



and provided with a hand lever 14. To adjust the depth of work the arm 6 has pivoted to it at its end a rod 15, having at the other end a stop collar 16, and sliding through one arm of a bell crank lever 17; the other arm of the bell crank 17 forms a hand lever, provided with a ratchet lever 18 adapted to engage in a rack 19 mounted on the frame 1. The axle 2 is provided with another arm 20, and the axle 4 with an arm 21, the arms 20 and 21 being connected by right and left-hand screw-threaded rods 22 engaging with a threaded barrel 23. To lift the plough a trigger 24 is pivotally carried on the cranked arm of the axle 2. To the trigger 24 a line 25 is attached by means of which the trigger can be turned to engage with one of the projections 26 on the land wheel 3. The engagement of the trigger 24 and the land wheel 3 causes the wheel and crank to turn together, and so to raise the plough. 27 is a cam mounted on the frame, and so shaped as to disengage the trigger when the plough is lifted out of work. 28 are the ploughing bodies and 29 is a trailing wheel. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c

138,464. B. A. Davey, London, and H. M. Hobson, Limited, London. Carburettors. (1 *Fig.*) March 13, 1919.—The invention relates to carburettors for internal-combustion engines, of the kind in which the float lever, and the valve seating and fuel inlet, are all arranged upon the cover of the float chamber. The fuel inlet A is formed in the centre of the cover B, and is provided with a seating C, on a detachable part C^2, for the valve D. The latter seats upwards and is guided in the seating part C^2, being merely a short stem with a tapered end D^2 which engages the seating C. To one side of the cover is pivoted at E^2 a lever E,



to the end of which is attached the float F. This is almost spherical in shape, and its upper surface, or the end of the lever at E^3, engages the underside of the valve. Thus, as the fuel level rises the float moves the valve on to its seating and as the level falls the float and valve move down. Stops are provided to limit the movement of the lever and prevent the valve D coming out of its guide, which is effected by causing a projection E^4 on the lever to lie in a recess B^2 in the cover B. Engagement of this projection with either side of the recess B^2 limits the travel of the lever and float in the corresponding direction. (*Sealed.*)

138,437. G. A. Robinson, Wolverhampton, and R. McNeill, Wolverhampton. Exhaust Silencers. (4 *Figs.*) February 17, 1919.—The invention relates to exhaust silencers for internal-combustion engines, comprising a scroll or volute formed from a single sheet of metal between the convolutions of which the exhaust gases flow outwardly from a central chamber, and consists in arranging that the outward passage through the convolutions constantly increases in cross-sectional area so as to allow the gases to be freely expanded as they flow outwards. The main body of the silencer comprises a cylindrical casing A, which is clamped between a pair of end caps B, B^1, by bolts. The caps are provided with flanges c within which the ends of the casing A fit. In the cap B is formed the inlet passage D for the exhaust gases, and in the cap B^1 is formed the outlet passage D^1. E is a sheet-metal scroll which has a central cylindrical portion e and a passage-way f extending from such central portion around the convolutions of the scroll and constantly increasing in depth. In the inner face of the cap B is formed a recess d, while in the inner face of the cap B^1 is formed a corresponding recess d^1 and into these recesses project extensions e^1, formed on the cylindrical portion e of the scroll, thus retaining the latter in place. The outward end of the scroll is supported by being wrapped

Fig. 1.

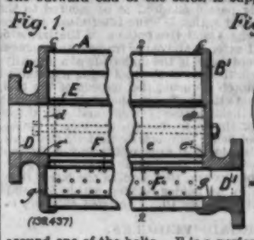


Fig. 2.

around one of the bolts. F is a perforated pipe which is carried at its one end within a recess g in the inner surface of the cap B, and at its other end, where it connects with the outlet D1, by a recess g^1 in the passage D^1 of the cap B^1. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

139,071. Herbert Morris, Limited, Loughborough, W. H. Purnell, Loughborough, and J. A. Butterworth, Loughborough. Jib Cranes. (1 *Fig.*) May 6, 1919.—The invention relates to portable jib cranes of the type constituted by three units each provided with wheels, one of the units carrying a post, the others being arranged with respect thereto in such manner as to contain between them a substantially V-shaped open space. The invention consists in a portable jib-crane comprising a carriage constituted by three triangularly arranged castings, each mounted on a wheel or wheels, steel flats constituting arms connecting one of said castings with the two remaining castings, said arms containing between them a substantially V-shaped open space, a tubular post mounted on said first-mentioned casting and a tubular jib connected to the post. The carriage is composed of three small castings 1, 2, 3, mounted on wheels,

Fig. 1.

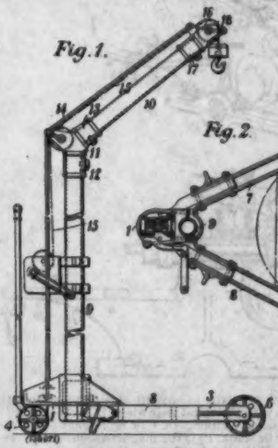
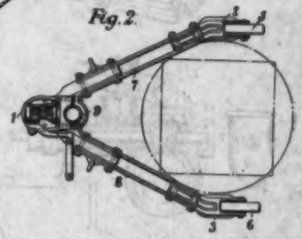


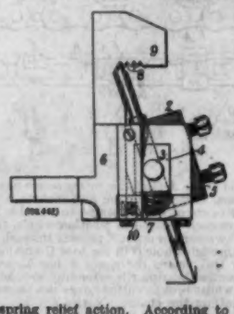
Fig. 2.



the casting mounted on the rear wheel 4 being connected with the castings 2, 3, mounted on the front wheels 5, 6, by steel flats 7, 8, rigidly attached to such castings, the flats 7, 8, diverging forwardly and containing between them a V-shaped space allowing the crane to be moved near the load to permit of a vertical lift. The post 9, which is supported on the rear casting 1, is of tubular formation, and is connected to the jib 10, which is also tubular, by a bracket 11 having tubular extensions 12, 13, in sleeve engagement with, and attached to, the post 9 and the jib 10, respectively, such bracket 11 being shaped to support in bearings a guide roller 14 for the lifting rope or chain 15. Attached to the outer end of the jib 10 is a bracket 16 having a tubular extension 17 in sleeve engagement with the outer end of the jib, such bracket being shaped at its outer end to support in bearings a guide pulley 18 for the lifting rope or chain 15. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

138,442. A. C. Twigg, Birmingham. Machine Tools. (7 *Figs.*) February 21, 1919.—The invention relates to machine tools for slotting and shaping, and of the type in which the tool is mounted upon a slide so as to have a direct thrust from the slide during the cutting stroke, but being adapted on the return movement to be released from direct engagement with the slide

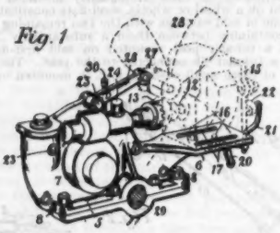


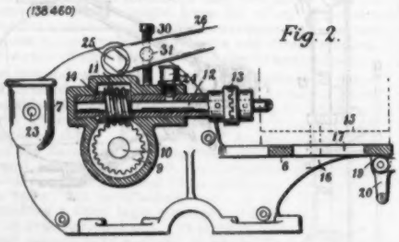
and given a spring relief action. According to the invention, a detachable tool is secured within a rocking or laterally-movable holder mounted upon the slide of the machine, which said slide carries a bracket or thrust member which directly engages and locks the end of the detachable tool during the working stroke, the tool-holder giving a relief action to the tool and releasing the end of the latter from the thrust member, during the return

movement. The tool 1 is fixed within a holder 2 which can pivot about a horizontal axis constituted by trunnions 3, 3, on the holder, turning within bearings in blocks 4 adapted to have a small vertical sliding movement within a rectangular frame or guide 5 carried by a body part 6 adapted to be secured to the slide of the machine, a coiled spring 7 being interposed between the lower end of the blocks 4 and the bottom of the frame 5. The upper end of the tool 1 extends above the frame 5 and engages one or other of a series of notches 8 in the underside of a laterally-projecting thrust bracket 9, the end of the tool being maintained in engagement with the notch 8 during the descent of the tool, by means of the spring 7. As the tool meets the work, and during the cutting stroke, it is held perfectly rigid and the thrust bracket 9 imparts a direct thrust to it. On the return stroke, the press rises and the tool being temporarily held by the work, the frame 5 moves over the blocks 4, causing the end of the tool to become free in the recess 8. The lower part of the guide frame then lifts the tool blocks and tool, and as the latter rises, it is given a relief action by its holder rocking within the slide blocks against the action of the spring 10. (*Accepted February* 18, 1920.)

MOTOR ROAD VEHICLES.

138,460. T. R. R. Chilcott, Sydney, Australia. Magnetos. (4 *Figs.*) March 11, 1919.—The invention relates to transmission gear and bracket for the magnetos of motor vehicles, and is especially adapted for vehicles not already provided with a magneto. According to the invention, the usual timing gear cover is substituted by a plate which supports a bracket having the gear cover cast or secured on it. The transmission gear comprises a spiral gear wheel driven from the camshaft and meshing with a spiral wheel on a shaft rotatable preferably in an eccentric bearing whereby adjustment may be made in the event of any difference of centres between the camshaft and that of the spiral wheel. 5 is a plate carrying a bracket 6 and having the gear cover 7 cast thereon and secured in position by bolts 8 in lieu of the usual timing gear cover. The spiral gear wheel 9

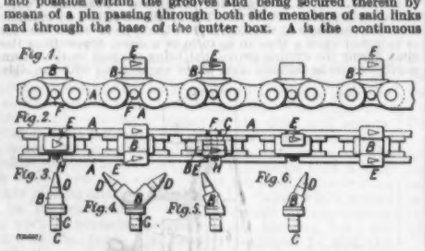




is on a shaft 10, which is driven in any suitable manner from the camshaft and meshes with the spiral gear wheel 11 on the magneto shaft 12, having the usual coupling 13. 14 represents a ball race to take the thrust of the shaft, 15 is the magneto secured by screw bolts 16 in the slots 17 in the bracket 6, the slots permitting the necessary adjustment. Pivoted at 19 is the bell crank lever 20, one arm coupling the connecting rod 21 to an interrupter 22. The opposite arm is connected to the usual pull rod, 23 is the breather oil opening and 24 an oil cup for lubrication of the shaft. Pivoted at 25 is the adjustable arm 26 carrying pulley 27 and radiator cooling fan 28 driven from a pulley on the drive shaft 29 by means of a belt, said arm being adapted to be fixed in its relative position by means of the adjustable stop pin 30 which passes through the pin 31 loosely held in said arm 26. (*Sealed.*)

MINING, METALLURGY, AND METAL WORKING.

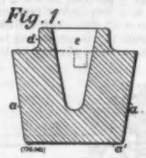
138,982. H. Clough, Morley, near Leeds. Coal Cutter Chains. (8 *Figs.*) February 6, 1919.—The invention consists in dispensing with the usual alternate block links carrying the cutters, and in the employment of a continuous roller chain, alternate links of which are internally grooved to receive a detachable cutter box, this cutter box being slid transversely into position within the grooves and being secured therein by means of a pin passing through both side members of said links and through the base of the cutter box. A is the continuous

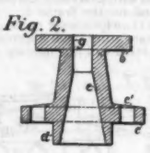


roller chain, and B the detachable cutter boxes having projecting bases C, and loose cutters D fitting into sockets E. These cutter boxes and cutters are of various single and double forms, and the cutter boxes are each secured in position within their respective chain grooves by means of a pin F passing through the chain-link members and through a hole G in the base C and locked by a split cotter H. By this means the chain A has a continuous roller bearing on a central bearing rib extending around both sides of the cutter jib, whilst broken cutter boxes can be readily renewed, without dismantling the chain. (*Sealed.*)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

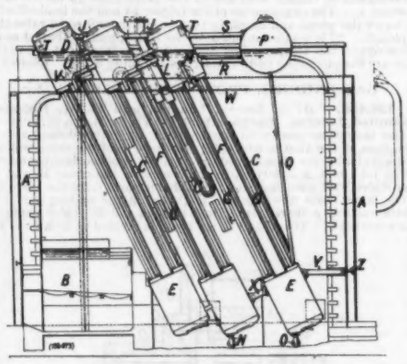
139,041. J. Mills, Manchester. Steam Gauge Mountings. (6 *Figs.*) March 26, 1919.—The invention relates to mountings for water steam gauges and feed valves. Such mountings consist of tubular distance pieces having end flanges for attachment to the boiler and gauge or other fitting, respectively, and a cylindrical through bore. According to the invention, the mounting is formed with a conical bore, the large end of which is at the boiler end of the fitting, said boiler end terminating in a spigot to enter a hole formed in the boiler plate to receive it. A blank *a* of steel is stamped in a die to form a truncated cone, the small end *a*1 being at the bottom of the die and the diameter of the bottom and top ends being equal to the diameters of the two flanges *b*, *c*, respectively. The top die is shaped to form a spigot *d* on the large flange *c*, and simultaneously a conical depression *e* extending the major portion of the way through the same. The dies are also shaped to form two diametrically opposite lugs on the periphery of the large flange. The stamping is subse-





quently turned in a lathe to true the flange faces and spigot and remove the surplus metal between the flange, the snugs ensuring a ready driving connection with the lathe. The lugs may be left on the completed article or may be removed when the block or mounting is machined. The top side *c*1 of the bottom flange *c* is inclined to facilitate the forming of the rivet heads by allowing the rivet head forming tool to clear the top flange *b*, and bed the rivet head squarely on the bottom flange. A short cylindrical boring *g* is made in the small end of the stamping to meet the conical depression *e*, the hollow cone or trumpet shape of which ensures easy flow of the fluids to and from the boiler. The flanges *b* and *c* are bored for connection to the boiler by riveting, and for the connecting of the gauge or other fitting. (*Accepted March* 3, 1920.)

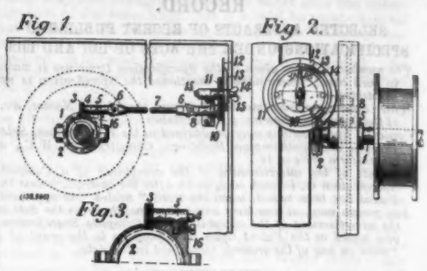
138,473. H. and T. Danks (Netherton), Limited, Netherton, and J. A. Danks, Southall. Water-tube Boilers. (3 *Figs.*) March 18, 1919.—The invention relates to sectional water-tube boilers. A is brickwork surrounding the boiler, B is a grate and C baffle plates or tubes guiding the gases through the boiler. Each section is composed of a top header D, a bottom header E, a large return tube F, and smaller tubes G connecting the top header to the bottom header. These tubes are inclined to the vertical so that the top header of each section is nearer the front of the furnace than is the bottom header. Each top header is provided with manholes so that all the small tubes may be withdrawn without interfering with the others, while each bottom header is provided with a manhole to admit a man for inspection and cleaning. The top headers of the various sections are connected together by steam nipples J, water level nipples K and water nipples L, while the bottom



headers of the front sections are connected by water nipples N, the object of all these nipples being to ensure the water circulating from one row to another to give a constant water level and to allow of the passage of steam to the storage cylinder. The feed water enters at M, being delivered to the top of the tubes F of the rearmost sections. It descends to the bottom headers of these sections where the impurities contained in the water will be deposited, and may be removed by blowoff pipes N and cocks O. P is a storage cylinder which is connected to the bottom headers of the back sections by tubes Q and to their top headers by water nipples R and steam nipples S. Brackets T connect the top headers together and to the outer sides of the top headers are secured shafts U, which rest in pedestals V on the top of the girders W, while the bottom headers are linked together by links X. The rear sides of the rearmost headers are connected by links Y to a transverse girder Z at the rear of the whole structure. (*Sealed.*)

TEXTILE MACHINERY.

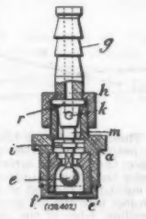
138,566. E. D. Bradley, Otley, G. Gray, Yeadon, and E. Gray, Yeadon. Measuring Material. (3 *Figs.*) September 16, 1919.—The invention relates to means for measuring and indicating continuous lengths of material for use in connection with textile milling machines, and comprises a shaft, a counterweighted indicating pointer loosely mounted thereon, means for connecting the pointer frictionally to the shaft, a scale for said pointer, and gearing connecting said shaft with a primary moving part of the milling machine. I is the main shaft of the milling machine on which is mounted a worm 2 that meshes with a worm wheel 3, the shaft 4 of which is supported in bearings in a bracket 5 adjustably secured to the worm cover 16. The shaft 4 is connected through two universal joints 6 and an intermediate shaft 7 with the one end of a shaft 8 that is carried in bearings in a bracket on the machine framing. On the other end of the shaft 8 is a pinion 10 that meshes with a spur wheel 11, the shaft 15 of which is also carried in bearings on the bracket. 12 is a dial scaled in yards, and mounted on the bracket. The shaft 15 extends through the centre of the dial 12 and on the projecting end is loosely mounted a pointer 13, which is secured thereto frictionally by a fly nut 14. The pointer 13 is counterweighted and, therefore, has a tendency, when the flynut 14 is unscrewed, to move to and occupy the position in which it is shown. When the milling machine is set in operation, the flynut 14 is screwed up to connect the pointer 13 with the shaft 15, the rotation of which through the gearing described drives the pointer in relation to the dial 12, and thus gives a direct reading or indication of the length of the piece of material that has passed



through the machine. When the machine is stopped, the flynut 14 is loosened and the finger or pointer 14 returns under the action of the counterweight of the zero position. (*Sealed.*)

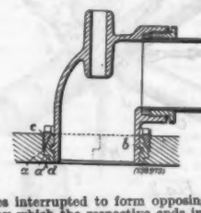
MISCELLANEOUS.

138,402. J. F. Holdcroft, Monkseaton. Hose Couplings. (1 *Fig.*) February 15, 1920.—The invention relates to a coupling of the type comprising a casing to be connected to a source of supply, a valve in the casing and a hollow tail-piece to be connected to a delivery pipe, the hollow tail-piece being provided with a coned head to bear on a seat in the casing and to strike a plunger to lift the valve off its seat. A valve in accordance with the invention has a ball valve enclosed in a renewable sleeve, which forms the seating of the valve, the ball being held in position by a retaining cap fitted with gauze, which acts as a filter for the fluid passing through the coupling. The valve is especially adapted for use with compressed air. The valve casing *a* is provided with an external thread adapted to be connected to any main service of air. The casing is screwed internally to



receive a metallic renewable valve seat *d*, in which a bronze ball *e* is adapted to work. A bronze gauze *e*1 is fitted in a screwed cap *f*, thus forming a cage for the ball *e* and acting as a filter for the passage of air. The coned tail-piece *g* is connected to the casing by a screwed coupling box *h*. The coned head is solid at the end, and is provided with hole *k* which is drilled right through the head and connecting to the main outlet in the tail-piece; *r* is a leather washer. Within the casing *a* is arranged a loose plunger *m* which works free in a slotted and fluted guide *i*, which is also loose, and which is prevented from leaving the casing by a shoulder turned in the casing, the plunger *m* is cottered on the underside of slotted guide *i*; which prevents plunger being forced out under pressure, or dropping out when in an inverted position. (*Sealed.*)

138,973. H. Woodgate, London, and A. Main, Whitley Bay, Northumberland. Pipe Joints. (3 *Figs.*) January 25, 1919.—The invention relates to mechanical joints, and is applicable for securing the liners in position within cylinders, for the mounting and connection of valve casings and pipes, and for the mounting and connection of tubular or cylindrical parts. The joint is of the kind wherein a jointing ring in one or more parts and having a conical exterior embraces one of the parts forming the connection, and is compressed thereon and against a seat provided upon the second part by a screw-threaded nut or bush having an interior conical face, and mounted upon the second part. A jointing ring *a* is divided into semicircular parts having



their end faces interrupted to form opposing protruding parts, and recesses by which the respective ends interengage to break the joint between them. Their inner faces are formed with an annular groove for the reception of the flange *b* formed on the end of the valve casing. Their outer faces are formed conical for the reception of the screw-threaded bush *c* which has an inner conical face, and is provided with notches by means of which the bush may be rotated to press the parts of the jointing ring *a* into tight contact with the valve casing or fitting. The parts of the jointing ring are formed with a shoulder *a*1 beneath the conical face, so that the pressure of the screw-threaded nut or bush holds the jointing ring on the seat formed for its reception upon the outwardly-extending flange *d* of the cylinder. (*Accepted March* 3, 1920.)

ENGINEERS' DESK BOOK AND DIARY.—We have received from **Trades Publicity Company, 38, Park-row, Leeds,** a desk book and diary which is now being issued to the engineering trade. It measures 8¼ in. by 5¼ in., and besides the diary portion, three days to a page, it contains much useful information on trade, tariffs, cartels, &c.; also physical and chemical notes; legal hints; statistics. A commercial gazetteer gives data on the British Empire and every country of the world.